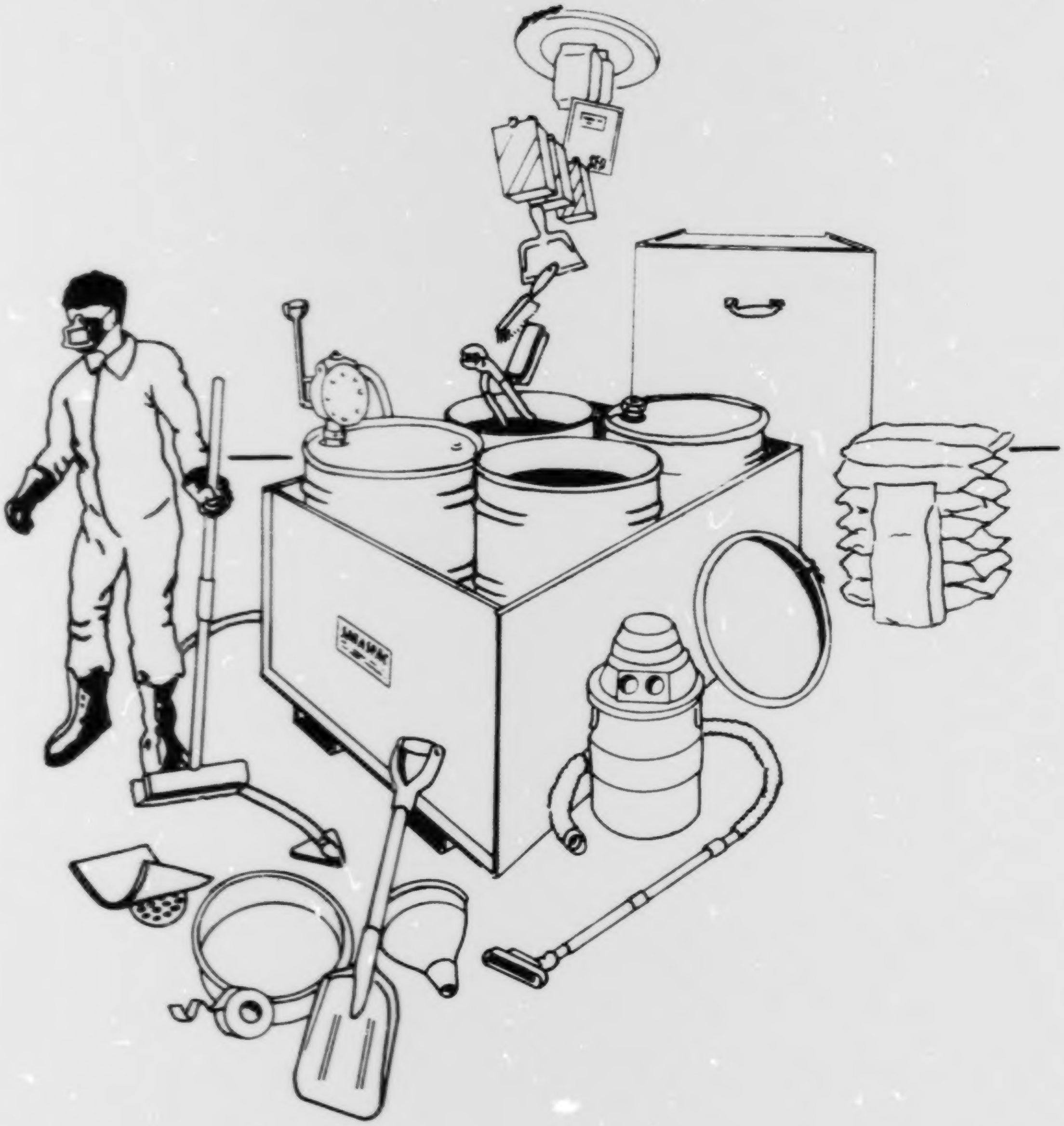
A Survey of Chemical Spill Countermeasures

Report EPS 9/SP/2
December 1986



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AT	Aquatic Toxicity
CC	Commercial Chemicals
CE	Consumers and the Environment
FP	Food Processing
HA	Hazardous Wastes
IC	Inorganic Chemicals
MA	Marine Pollution
MM	Mining & Mineral Processing
NR	Northern Regions
PF	Paper and Fibres
PG	Power Generation
PN	Petroleum and Natural Gas
SP	Oil & Chemical Spills
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UP	Urban Pollution

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EPS 9/SP/2 June 1987

A Survey of Chemical Spill Countermeasures

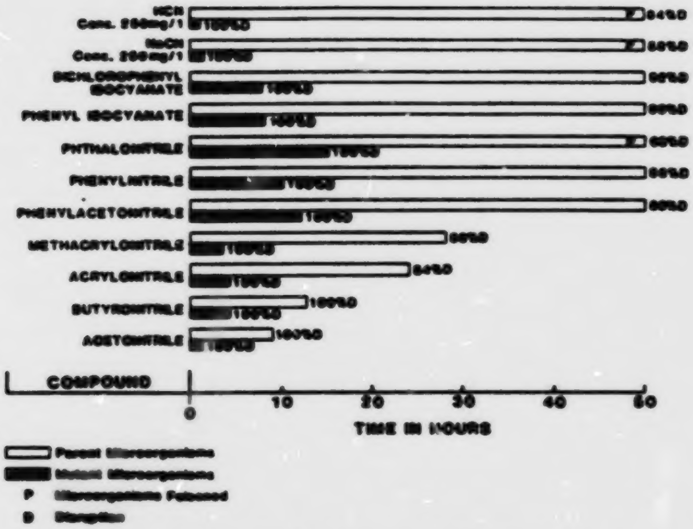
ERRATUM

Page 365, please insert the following under PERFORMANCE:

POLYBAC, MUTANT BACTERIAL
HYDROCARBON DEGRADER

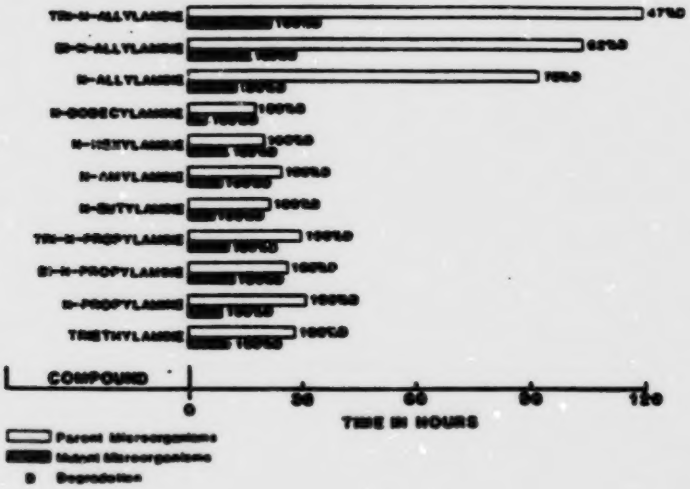
CYANIDES DEGRADATION TIME

BY PARENT AND MUTANT MICROORGANISMS @ 20°C.
(Conc. 500mg./1 unless otherwise noted)



ALIPHATIC AMINES DEGRADATION TIME

BY PARENT AND MUTANT AEROBACTER SP @ 20°C
(Conc. 200mg./ 1 unless otherwise noted)



POLYBAC, MUTANT BACTERIAL
HYDROCARBON DEGRADER

ARYL HALIDES DEGRADATION TIME

BY PARENT AND MUTANT PSEUDOMONAS SP @ 30°C
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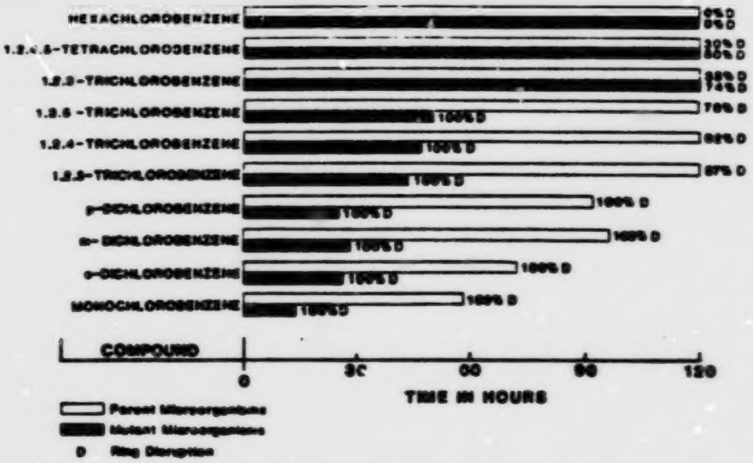
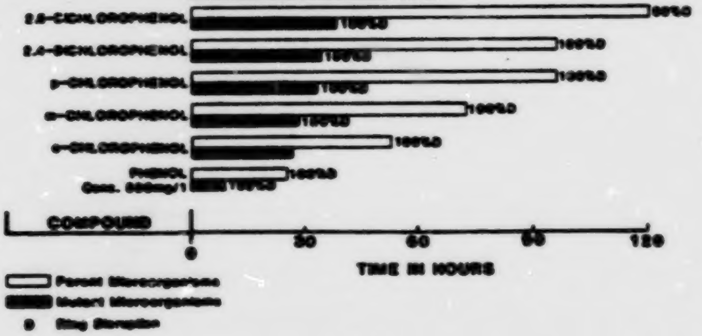


HALOPHENOLS DEGRADATION TIME

BY PARENT AND MUTANT PSEUDOMONAS @ 30°C.
(Conc. 200mg./1 unless otherwise noted)



A SURVEY OF CHEMICAL SPILL COUNTERMEASURES

by

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for the

Environmental Emergencies Technology Division
Technology Development and Technical Services Branch
Conservation and Protection
Environment Canada

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ABSTRACT

Information on conceptual, prototype, and commercially available equipment, processes, agents and techniques for controlling spills of hazardous materials is provided in this report. In order to facilitate use as a guide, information has been categorized according to the primary response operation to which it can be applied, namely: containment, removal, temporary storage, transfer, ultimate disposal, and ancillary equipment.

RÉSUMÉ

Le présent rapport contient des renseignements sur les engins, les procédés, les agents et les techniques (qui en sont à l'étape de la conception, du prototype ou de l'exploitation commerciale) de lutte contre les déversements de matières dangereuses. Pour faciliter la consultation, les renseignements sont classés selon la nature de l'opération principale envisagée: encerclement, endiguement ou localisation; nettoyage ou récupération; stockage temporaire; transfert ou transbordement; élimination finale; équipement auxiliaire ou d'appoint.

FOREWORD

The information contained in this report was compiled by Mr. L.B. Solsberg and Mr. R.D. Parent of S.L. Ross Environmental Research Limited under contract to Environment Canada. The document is based on a draft version prepared by M.M. Dillon Ltd. of Toronto and was released for comment in February 1982. The data obtained are believed to be accurate as of July 1984 or earlier where specifically noted in individual entries. The use envisaged for this publication is as a reference source for those with responsibilities relating to hazardous material spills countermeasures. It is not intended as a comprehensive field manual for first responders nor is its application as such encouraged whatsoever.

ACKNOWLEDGEMENTS

The manufacturers, distributors and developers of spill control technology are acknowledged for their provision of technical data on which the entries for this survey are based. This involved personal communications and the submission of brochures, reports and papers. Extensive use was also made of file literature maintained by Environment Canada comprised of conference proceedings, manufacturers' sales information, technical journals, handbooks, and other publications. In particular, Mr. M.F. Fingas of the Environmental Emergencies Technology Division is thanked for his guidance and assistance throughout the work. The U.S. Environmental Protection Agency at Edison, NJ is acknowledged for providing comprehensive information detailing projects that the EPA has undertaken in hazardous material spill research and development.

Funding to facilitate the publication of this updated and revised draft survey was made available by the American Association of Railroads. Illustrations for the document were the work of Mr. B.A.K. Townshend of Environment Canada.

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INTRODUCTION

This survey is a compilation of state-of-the-art countermeasures conceived primarily for the control of hazardous material spills. The information presented is based, in part, on a report prepared by M.M. Dillon Ltd. of Toronto, Ontario for Environment Canada and released in draft form for comment in February 1982. This revised and updated document considers data made available to the Environmental Emergencies Technology Division up to December 1983. Verification of these data continued until July 1984.

Time constraints associated with the study resulted in North American sources being the primary contacts. These same limitations also make it important to point out that, in some cases, equipment and materials reviewed were representative of a particular group of cleanup technology only. An attempt was made, however, to include contact information and references to supplement the products and ideas discussed. Also, to this end, 15 general listings or comprehensive reviews were prepared on subjects either too broad in scope to delve into during the course of this work or which would have required an arbitrary and perhaps inappropriate selection of few processes or hardware.

All entries, including the detailed, individual listings as well as the more general reviews have been organized into separate sections within the catalogue which reflect the cleanup operation to which they would likely be applied and in an order in which they might be used.

For each of the detailed, individual entries and several of the general listings, data have been catagorized under the following subsections:

Applicability,
Description,
Operating Principle,
Physical Specifications,
Operating Specifications,
Status of Development and Usage,
Performance,
Availability and Commercial Information, and
Other Data.

For the most part, these are self-explanatory. "Applicability", refers to the behavioural group to which the device or concept should be considered for use and includes gases as well as soluble (sol), floating (fl) and sinking (sk) liquids and solids. The "Description" often includes both narrative and graphic components. These should prove useful in obtaining a better understanding of the "Operating Principle" and, in some instances, the "Physical Specifications" which follow.

The reader should also note that individual entries have been classified insofar as the "Status of Development" is concerned so that the heading PRODUCT, PROTOTYPE or CONCEPT appears at the top of each. Entries have been numbered to facilitate use of the catalogue as a guide as well as for easier cross-referencing. In this regard, two Indexes have been prepared which further assist locating information.

The first Index contains a detailed list of all entries arranged in numbered, sequential order according to cleanup operation. The second Index is organized on a company-by-company basis and should enable any entry to be referenced if only the company name is known.

Two brief Appendices provide additional information. Appendix A contains a list of cleanup contractors while Appendix B refers to Canadian chemical suppliers.

When using this catalogue, it should also prove helpful to be aware that devices and ideas have been included that have been evaluated, have proven performance, or were judged to have potential merit for hazardous material spill response. Exclusions from the survey include: home remedies, personal protection equipment, detection, tracking and remote sensing hardware, devices with exclusive oil spill application, communication gear, and long-term prevention or disposal techniques.

This catalogue, as such, should prove useful for those either purchasing or implementing spill countermeasures. Another of its foreseen applications is as an assessment tool for establishing future, related research and development priorities by industry and government alike.

NOMENCLATURE

abs	absolute pressure
a/b	Telex number answer back
bhp	brake horsepower
BOD	biological oxygen demand
cm	centimetre
COD	chemical oxygen demand
cSt	centistokes
°C	degrees Centigrade
°F	degrees Fahrenheit
ft	feet
ft^2	square feet
ft^3	cubic feet
h	hour
ha	hectare
hp	horsepower
Hz	Hertz (cycles per second)
I.D.	internal diameter
in	inch
kg	kilogram
km	kilometre
kPa	kilopascal
kVA	kilo volt-ampere (kilowatt)
kW	kilowatt
L	litre
lb	pound
m	metre (m^2 = square metre, m^3 = cubic metre)
M	molar
mi	mile
min	minute
mm	millimetre
MPa	megapascal
N-m	Newton-metre
No.	number
OHMSETT	Oil and Hazardous Materials Simulated Environmental Test Tank
%	percent
Ø	phase (re: electric motors)
oz	ounce
pH	logarithm of the reciprocal of the hydrogen ion concentration
ppb	parts per billion
ppm	parts per million
psi	pounds per square inch
psia	pounds per square inch absolute
psig	pounds per square inch gauge
qt	quart
rph	revolutions per hour
rpm	revolutions per minute
s	second
t, tonne	metric ton (1 tonne = 1000/kg)
®	registered trademark
U.S. gal	U.S. gallons (= 3.79 L)
U.S. GPH	U.S. gallons per hour
U.S. GPM	U.S. gallons per minute
V	volt
VAC	volts, alternating current
VDC	volts, direct current
W	watt

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This index is organized according to the response operation to which the equipment or concept can be applied.

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Company Name	Product No.	Description
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Cardinal Rubber & Seal Inc.	120	Acid, Chemical Hoses
Carlisle Tire and Rubber Co.	25	Mechanical Covers
	93	Polymeric Membranes
Carolina Slurry Systems	11	Bentonite Soil Sealing Systems
Cassier Engineering Sales, Ltd.	87	Bulkdrum
Celanese Canada Inc.	80	Section H Precipitation, Flocculation and Sedimentation
Central Engineering Co., Inc.	40	Large Suction Devices
Charles R. Dow Equipment	55	Crisafulli Sludge Handling System
Chase-Walton Elastomers, Inc.	120	Acid, Chemical Hoses
Chemfix Technologies Inc.	132	Fixation Technology
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Company Name	Product No.	Description
Chemical Separation Corp.	80	Section G Ion Exchange
The Chlorine Institute, Inc.	1	Chlorine Institute Emergency Kits A, B and C
CIBA - Geigy	11	Bentonite Soil Sealing Systems
C-I-L Inc.	11	Bentonite Soil Sealing Systems
City Industrial Sales Corp.	120	Acid, Chemical Hoses
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Clearing Container	86	Salvage Drums
Code 4 Rescue	154	Lamp-Lifter Air Cushions
Columbia Reservoir Systems Ltd. (Restech)	92	Unitized Portable Reservoir System
Comar, Inc. (formerly Moorehead Engineering Co.)	31	Mobile Surface Cleaner
Compressed Gas Association, Inc.	3	Emergency Safety Kit for VCM Tank Cars
Compro - Vac Division of Valve-All Canada Ltd.	119	Bush Vacuum Pump
Conenco International Limited	23	Portadam Oil Barrier
Construction Aids Technology Inc.	6	Plug N'Dike
Conwed Corporation	48	Conwed D-Sorbent Pads
Crane Co.	80	Section G Ion Exchange
Crisafulli Pump Company, Inc.	55	Crisafulli Sludge Handling Systems
	98	Crisafulli Pumps
Cyanimid Canada Inc.	80	Section H Precipitation, Flocculation and Sedimentation
The D&D Group, Inc.	125	Diesel Engine Incinerator
Demco Incorporated	64	Demco Hydrocyclones
Development Sciences, Inc.	157	Remote Controlled Hovercraft Vehicle for Spill Reconnaissance
Diamond Shamrock Corporation	49	Hazorb
Dow Chemical Company	50	Imbiber Beads
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DP Way Corporation	40	Large Suction Devices

Company Name	Product No.	Description
Dravo Lime Co.	132	Fixation Technology
Dresser Minerals	11	Bentonite Soil Sealing Systems
DSMA Atcon Ltd.	26	Mobile Gas Dispersion System
Dunlop Limited (GRG Division)	81	Flexible Tanks
	120	Acid, Chemical Hoses
Dutra Slurry Systems	11	Bentonite Soil Sealing Systems
Dynacraft	120	Acid, Chemical Hoses
Dynesco Equipment Sales Ltd.	100	Fybroc Fiberglass Pumps
Ecodyne	80	Section G Ion Exchange
Edwards & Cromwell Manufacturing, Inc.	2	Edwards & Cromwell Emergency Package
E.I. Du Pont de Nemours & Company, Inc.	93	Polymeric Membranes
EMCO Inc.	50	Imbiber Beads
Empex Industrial Hose	120	Acid, Chemical Hoses
Energetex Engineering	124	Cleanfire Portable Incinerator
Energy Resources Company, Inc.	151	Composting and Land Farming
ENSCO (Energy Systems Co.)	50	Imbiber Beads
Envirex Inc.	69	EPA Mobile Physical/Chemical Treatment Trailers
Environmental Container Corp.	32	Enviropac PCB Removal Kit
Environmental Processing Systems (EPS), Inc.	135	EPS Mobile Processing and Transfer Unit
Environmental Protection Polymers, Inc.	7	Polymeric Encapsulation of Containerized Hazardous Materials
Environmental Technology Corp.	132	Fixation Technology
	133	Bentonite/Cement Fixation Process
Environment Canada	21	Spill Containment Barriers (catalogue)
	23	Portadam Oil Barrier
	36	Mechanical Skimmers (catalogue)
	46	Spill Sorbents
	71	Mobile Ultrafiltration/Reverse Osmosis Unit
Epton Industries	120	Acid, Chemical Hoses
E.S. Clark Associates, Inc.	74	Chem-gel and Indusorb
Federal Bentonite (Ashcono Chemical)	11	Bentonite Soil Sealing Systems

Company Name	Product No.	Description
Flexaust Canada Ltd.	120	Acid, Chemical Hoses
Flex Incorporated	120	Acid, Chemical Hoses
Fluid Automation, Inc.	116	U.S. Coast Guard ADAPTS Pumping System
Fluid Solids Inc.	21	Spill Containment Barriers
Flygt Canada	99	Flygt Submersible Pumps
FMC Corporation	80	Reference 8, Section C Chemical Oxidation/Reduction
Frank Ayles & Associates Ltd.	39 45	Small Suction Systems Spillvac Vacuum Unit
Franklin Institute Research Laboratory, Inc.	143	NaPEG™ System
Frank Mohn Fusa A/S	101	Framo Submersible Pumps
Frank Mohn Houston, Inc.	101	Framo Submersible Pumps
Gates Canada Inc.	120	Acid, Chemical Hoses
Gates Rubber Company	122	Gates Chemical Handling Hose
George Mann and Company Inc.	16	George Mann Chemergency Kit
Georgian Bay Fire & Safety Supplies Ltd.	6	Plug N'Dike
Gilkes Pumps Inc.	102	Gilkes 3.25 F Portable Emergency Turbo Pump
Globe Linings, Inc.	25	Mechanical Covers
Goodall Rubber Co.	123	Goodall Chemical Hose
Goodall Rubber Co. of Canada Ltd.	120 123	Acid, Chemical Hoses Goodall Chemical Hose
Goodyear Canada Inc.	120	Acid, Chemical Hoses
Goodyear Rubber Products Corp.	120	Acid, Chemical Hoses
Goodyear Tire and Rubber Co.	93 147	Polymeric Membranes Sodium Naphthalide Method for Disposal of PCBs
Gourock Industries	109	Marco U101 Capsulpump
Greif Containers Inc. (Canada)	86	Salvage Drums
Greif Bros. Corporation	86	Salvage Drums
Ground Engineering Ltd.	11	Bentonite Soil Sealing Systems
Ground Slurry Systems, Inc.	11	Bentonite Soil Sealing Systems

Company Name	Product No.	Description
Groundwater Technology, Inc.	38	Scavenger Portable Separator
Gulf Seal Corp.	25	Mechanical Covers
Gundle Lining Systems	93	Polymeric Membranes
Harrier Marine Limited	39	Small Suction Systems
	42	Harrier Hi-Vac Vacuum Units
Hoover Universal, Inc.	87	Bulkdrum
Hose Technology Inc.	120	Acid, Chemical Hoses
HP Power Devices Ltd.	120	Acid, Chemical Hoses
Hydro Dynamics Ltd.	94	American Teflon and Polypropylene Pumps
Illinois Water Treatment	80	Section G Ion Exchange
Indian Springs Mfg. Co., Inc.	1	Chlorine Institute Emergency Kits A, B and C
Industrial and Municipal Engineering	40	Large Suction Devices
Industrial Bio-Test Laboratories, Inc.	66	Dynactor
Industrial Plastics Canada Ltd.	4	Milsheff Spray-Stop Valve and Flange Covers
Industrial Sales Ltd.	120	Acid, Chemical Hoses
Industrial Services International, Inc.	74	Chem-gel and Indusorb
Infilco	80	Section G Ion Exchange
Ingersoll-Rand Canada Inc.	103	Ingersoll-Rand GRP Pumps
Ingersoll-Rand Company	103	Ingersoll-Rand GRP Pumps
Insta-Foam Products, Inc.	15	Froth-Pak Portable Foam System
Insulated Duct & Cable Company, Inc.	120	Acid, Chemical Hoses
International Minerals and Chemical Corp. (Imcore Division)	11	Bentonite Soil Sealing Systems
IPC Systems, Inc.	63	Carbtrol Adsorption Canisters
IPM Supplies Ltd.	120	Acid, Chemical Hoses
ITT Industries of Canada Limited	95	Bell & Gossett Centrifugal Pumps
I.U. Conversion Systems, Inc.	132	Fixation Technology
Jebco Slurry Associates (Jebco Slurry Systems)	11	Bentonite Soil Sealing Systems
Jerry Bros. Belting Co., Inc.	120	Acid, Chemical Hoses
Johnston Industrial Plastics Ltd.	120	Acid, Chemical Hoses

Company Name	Product No.	Description
John Vissers Sales Corp.	96	Chemtrol Centrifugal Pumps
	97	Corcoran Centrifugal Pumps
	104	Kontro Seal-less Pumps
	107	Lutz Drum Pumps
	113	Serfilco Centrifugal Chemical Pumps
JRB Associates	12	Capture and Containment Bag
	14	Foamed Concrete Barrier System
	34	Subsurface Soil Surfactant
J.T. Baker Chemical Company	79	Patented Spill Control Compositions
Kepner Plastics Fabricators, Inc.	81	Flexible Tanks
Kingston Eric Sales Ltd.	120	Acid, Chemical Hoses
Kleber Marston Products	81	Flexible Tanks
Kleener Kleener Inc.	40	Large Suction Devices
The Kontro Company, Inc.	104	Kontro Seal-less Pumps
Kuriyama of America, Inc.	120	Acid, Chemical Hoses
Lab Safety Supply	53	Spill Control Pillows
Law Engineering Testing Co.	10	Artificial Ground Freezing
Lawjack Engineering Ltd.	120	Acid, Chemical Hoses
Levitt-Safety Ltd.	29	Vapour Suppressing Foams
Lexcan Industrial Supply Ltd.	93	Polymeric Membranes
LFE Canada Limited	105	LFE Magnetic Drive Pumps
LFE Corporation	105	LFE Magnetic Drive Pumps
Little Giant Pump Company	106	Little Giant Magnet-Driven Chemical Pumps
L.T. Industries	120	Acid, Chemical Hoses
Lutz Pumps, Inc.	107	Lutz Drum Pumps
Mandem	118	Wilden Air-Operated Diaphragm Pumps
Manierre Corporation	39	Small Suction Systems
March Manufacturing, Inc.	108	March Chemical Pumps
Marine Construction & Design Company	109	Marco U101 Capsulpump
Marine Pollution Control	115	Thune-Eureka Portable Submersion Pumps
Maritime Hydraulics and Machinery	101	Framo Submersible Pumps
Mateson Chemical Corp.	77	Muck-up Adsorbent/Solidifying Agent

Company Name	Product No.	Description
Megator Corporation	110	Megator Sliding-Shoe Pumps
Memtek Corporation	71	Mobile Ultrafiltration/Reverse Osmosis Unit
Met-Pro Corporation	67	EPA/Met-Pro Independent Physical/ Chemical Wastewater Treatment System
	100	Fybroc Fiberglass Pumps
Miller Plastics	108	March Chemical Pumps
Modar Incorporated	142	Modar Supercritical Water Oxidation Process
Modutank, Inc.	90	Modular Holding Tanks
	93	Polymeric Membranes
MSA Canada	18	MSAR Dike-Pak System
	27	MSA Portable Foamaker
	29	Vapour Suppressing Foams
	160	Solids Broadcaster (MSA Rockduster)
MSA Research Corporation	12	Capture and Containment Bag
	14	Foamed Concrete Barrier System
	18	MSAR Dike-Pak System
	20	Soil Surface Sealing
	27	MSA Portable Foamaker
	29	Vapour Suppressing Foams
	30	Vapour Suppression by Artificial Cooling
	33	Soil Extraction System
	59	Activated Carbon Regenerator
	81	Flexible Tanks
	83	Portable Collection Bag System
	160	Solids Broadcaster (MSA Rockduster)
Multiquip Inc.	112	Multiquip QP Stainless Steel Pumps
Nat Aranson and Associates	120	Acid, Chemical Hoses
National Car Rental Systems, Inc. (Mud Cat Division)	56	Mudcat Auger Dredging Unit
National Foam Systems, Inc.	29	Vapour Suppressing Foams
Nepcco	37	Petropurge Groundwater Decontamination System
Nevtro Sales Ltd.	120	Acid, Chemical Hoses
NFE Canada Ltd.	39	Small Suction Systems
	40	Large Suction Devices
	43	NFE Hi-Vac Vacuum Cleaners/Conveyors
NFE International Ltd.	39	Small Suction Systems
	40	Large Suction Devices
	43	NFE Hi-Vac Vacuum Cleaners/Conveyors
Nilfisk Ltd.	39	Small Suction Systems

Company Name	Product No.	Description
Nilfisk of America Inc.	39 44	Small Suction Systems Nilfisk Mercury Vacuum Cleaner
NL Industries Inc. (Bariod Division)	11	Bentonite Soil Sealing Systems
Nortech Corporation	39	Small Suction Systems
NRC Inc.	5	NRC Tantalum Patch Kit
Oil Recovery International	81	Flexible Tanks
Oil Recovery Systems, Inc.	38 57 60	Scavenger Portable Separator Activated Carbon Adsorber Water Purification System Air Stripping Water Purification System
Omniflex Industrial Sales Ltd.	120	Acid, Chemical Hoses
Ontario Hose Specialities Ltd.	120	Acid, Chemical Hoses
Ontario Liquid Waste Disposal Ltd.	132	Fixation Technology
Ontario Research Foundation	149	Ontario Research Foundation Wetox Process
Ontario Rubber	120	Acid, Chemical Hoses
Ontor Limited	106	Little Giant Magnet-Driven Chemical Pumps
Pantasote Company of New York Inc.	93	Polymeric Membranes
Pantek Industrial Products	120	Acid, Chemical Hoses
Paratech Incorporated	156	Maxiforce Lifting Bags
Peabody Myers	40	Large Suction Devices
Peacock Incorporated	114	SPATE Induced Flow Pump
Pec Engineering	132	Fixation Technology
Pedsco Canada Ltd.	158	RMI (Remote Mobile Investigator)
Permutit	80	Section G Ion Exchange
Petro-Trap	51	Petro-Trap
Plastic Systems, Inc.	25	Mechanical Covers
Polybac Corporation	152	Polybac, Mutant Bacterial Hydrocarbon Degrader
Polyquip Incorporated	112	Multiquip QP Stainless Steel Pumps
Power-Vac, Inc.	40	Large Suction Devices
PPM Incorporated	144	PPM Inc. Mobile PCB Destruction Process
Prenco Incorporated	128	Prenco Mobile Incinerator

Company Name	Product No.	Description
Pronal SA	81	Flexible Tanks
Pyro-Magnetics Corporation	130	Pyromagnetics Mobile Incinerator
QIP Equipment Limited	120	Acid, Chemical Hoses
Quincy Adams Marine Basin Inc.	21	Spill Containment Barriers
Resinol Plastic Industries Ltd.	120	Acid, Chemical Hoses
Response Systems, Inc.	82	Diodon Flexible Tank
Rexnord Inc.	17	In-Situ Containment and Treatment Systems
	33	Soil Extraction System
River Rubber and Belting Company, Inc.	120	Acid, Chemical Hoses
RNG Equipment	38	Scavenger Portable Separator
Robbins & Myers Company of Canada Limited	111	Moyno Progressing Cavity Pumps
Robbins & Myers, Inc.	111	Moyno Progressing Cavity Pumps
Rockwell International	8	Rockwell External Leak Plugging System
	127	Mobile Molten Salt Destruction Unit
	139	The Bromination Process
Rockwood Systems Corporation	29	Vapour Suppressing Foams
Rohm and Haas	80	Section G Ion Exchange
	80	Section H Precipitation, Flocculation and Sedimentation
Romicon, Inc.	70	Hollow Fiber Ultrafiltration (UF) System
R.S. Corcoran Company	97	Corcoran Centrifugal Pumps
Safety Supply Co. (Canada)	9	Vetter Sealing Bag
	161	Vetter Power Lifting Bags
Samson Ocean Systems, Inc.	24	Sea Curtain Barrier
Sanivan Inc.	6	Plug N'Dike
	19	Sanitrap Hole Cover
	37	Petropurge Groundwater Decontamination System
	40	Large Suction Devices
	49	Hazorb
Sarnafil Canada Limited	93	Polymeric Membranes
Schlegel Lining Technology Inc.	93	Polymeric Membranes
Scientific Service, Inc.	22	Mobile Stream Diversion System
Seaman Corporation (Shelter-Rite)	93	Polymeric Membranes
SED, Incorporated	32	Saraspac PCB Removal Kit

Company Name	Product No.	Description
Serfilco	113	Serfilco Centrifugal Chemical Pumps
Service Rubber and Gasket Company, Inc.	120	Acid, Chemical Hoses
Shelter-Rite (Division of Seaman Corporation)	93	Polymeric Membranes
Shenandoah Industrial Rubber Company	120	Acid, Chemical Hoses
Sinclair MacDonald Products	39 41	Small Suction Systems Hako Minuteman Vacuum Systems
Skimmex Ltd.	81	Flexible Tanks
Skolnik Drum Corporation	86	Salvage Drums
Slickbar, Inc.	4	Milsheff Spray-Stop Valve and Flange Covers
Sludge Fixation Technology Inc.	132	Fixation Technology
SMS Limited	108	March Chemical Pumps
Snap-Tite Hose, Inc.	120	Acid, Chemical Hoses
Soil Recovery, Inc.	148	The Soil Recovery Process
Soper's Engineered Fabric Products	81 84	Flexible Tanks Port-A-Tank
Sorbco	48	Conwed D-Sorbent Pads
Stabatrol Corporation	132	Fixation Technology
Stablex Corporation	132	Fixation Technology
Stevens Elastomeric and Plastic Products Inc.	93	Polymeric Membranes
Sun-Flow, Inc.	120	Acid, Chemical Hoses
SUNOHIO Company	145	SUNOHIO PCBX Process
Super Products	40	Large Suction Devices
Task Force Enterprises	92	Unitized Portable Reservoir System
Taylor-Parker Co., Inc.	120	Acid, Chemical Hoses
Technotherm Inc.	104	Kontro Seal-Less Pumps
Thatcher Engineering Corp. (Slurry Systems)	11	Bentonite Soil Sealing Systems
Thompson-Chemtrol	96	Chemtrol Centrifugal Pumps
3M Canada Inc.	29	Vapour Supressing Foams
3M Company	29	Vapour Supressing Foams

Company Name	Product No.	Description
Thune-Eureka A/S	115	Thune-Eureka Portable Submersible Pumps
TJK, Inc.	132	Fixation Technology
TOPP Hygienics Ltd.	47	Absol Absorbent and Flame Retardant
Transport Canada	26	Mobile Gas Dispersion System
Transtech Container Systems Company, Ltd.	81	Flexible Tanks
Transway Systems, Inc. (formerly J.B. Systems Ltd.)	40	Large Suction Devices
Trecan Limited	131	Trecan Portable Incinerator
Trelleborg AB	81	Flexible Tanks
Triangle Resource Industries (TRI)	35	TRITEK Transportation Emergency Kit
	136	TRIPAK Liquid Solidification Compound
TRW Systems Group	132	Fixation Technology
Uniroyal Inc.	21	Spill Containment Barriers
	81	Flexible Tanks
	120	Acid, Chemical Hoses
United McGill Corp.	21	Spill Containment Barriers
United States Testing Company Inc.	78	Spill/Clean Gelling Agent
University of California	140	Degradation by Superoxide
University of Lowell	73	Amine Carbamate Gelling Agent and Application System
U.S. Coast Guard	28	Vapour Reduction Device (VRD)
	116	U.S. Coast Guard ADAPTS Pumping System
U.S. Ecology	91	Repository for Fissile Materials
U.S. Environmental Protection Agency	7	Polymeric Encapsulation of Containerized Hazardous Materials
	8	Rockwell External Leak Plugging System
	12	Capture and Containment Bag
	14	Foamed Concrete Barrier System
	17	In-Situ Containment and Treatment System
	20	Soil Surface Sealing
	22	Mobile Stream Diversion System
	24	Sea Curtain Barrier
	25	Mechanical Covers
	30	Vapour Supression by Artificial Cooling
	33	Solvent Extraction System
	34	Subsurface Soil Surfactant
	46	Spill Sorbents
	58	Activated Carbon Application in Flowing Streams
	59	Activated Carbon Regenerator
	65	System for Application of Slurried Carbon to Surface Waters

Company Name	Product No.	Description
	66	Dynactor
	67	EPA/Met-Pro Independent Physical/ Chemical Wastewater Treatment System
	68	EPA Mobile Flocculation-Sedimentation System
	69	EPA Mobile Physical/Chemical Treatment Trailers
	76	EPA Multipurpose Gelling Agent
	83	Portable Collection Bag System
	126	EPA Mobile Incineration System
	139	The Bromination Process
	157	Remote Controlled Hovercraft Vehicle for Spill Reconnaissance
Vac-U-Max	39	Small Suction Systems
Valve-All Canada Ltd.	119	Busch Vacuum Pump
Versatech Products Inc.	81	Flexible Tanks
Vetter Systems	9	Vetter Sealing Bag
	161	Vetter Power Lifting Bags
Vibro-Flo Inc.	120	Acid, Chemical Hoses
Vikoma International Ltd.	39	Small Suction Systems
Wajax Industries Ltd.	40	Large Suction Devices
The Warren Rupp Co.	117	Warren Rupp VIP Sandpiper Pumps
Washington State University	132	Fixation Technology
Werner and Pfleiderer Corp.	132	Fixation Technology
	137	Volume Reduction and Solidification System (WPC - VRS)
Westgate Research Corp.	146	Westgate Ultrox (UV - Oxidizer) Process
Wilden Pump and Equipment Co.	118	Wilden Air - Operated Diaphragm Pumps
William R. Selwood Ltd.	114	SPATE Induced Flow Pump
Wilson & Cousins	156	Maxiforce Lifting Bags
Wizard Drum Tools	155	Manual Drum Deheader
	162	Wizard Self-Propelled Drum Deheader
Wm. W. Myers & Sons Inc.	40	Large Suction Devices
Wormald CDN Inc.	29	Vapour Suppressing Foam
Wormald U.S. Inc.	29	Vapour Suppressing Foam
Wreckers International Ltd.	159	Safelift Air Cushion System
Wyo-Ben Inc.	11	Bentonite Soil Sealing Systems
York Fluid Controls Ltd.	118	Wilden Air-Operated Diaphragm Pumps

Company Name	Product No.	Description
Zimpro Inc.	72	PACT Mobile Wastewater Treatment System
	150	Zimpro Wet Air Oxidation Process
Zumro Inc.	154	Lampe-Lifter Air Cushions

1 CONTAINMENT

1 CONTAINMENT

1.1 Leak Mitigation

PRODUCT CHLORINE INSTITUTE
EMERGENCY KITS "A" "B" AND "C" **No. 1**

APPLICABILITY

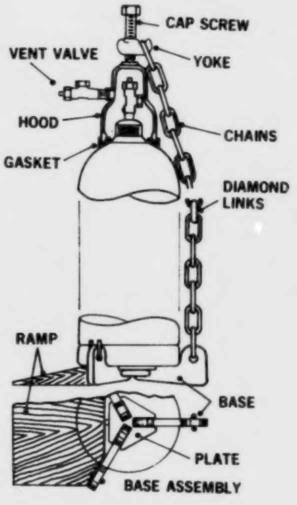
Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
*	*	*	*			

(see also Status of Development and Usage)

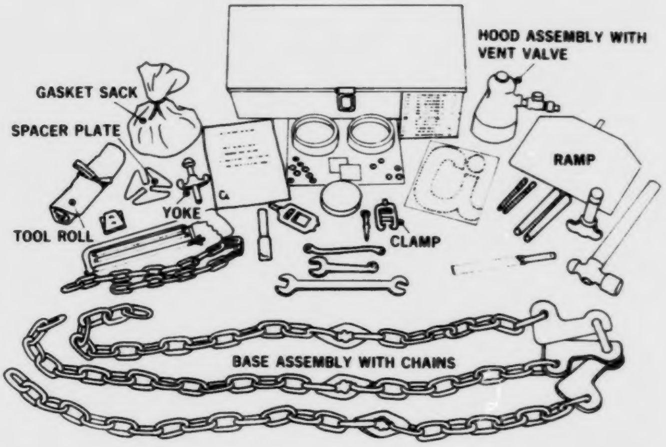
DESCRIPTION – Emergency Kit A contains tools and devices designed to stop and/or contain leaks in the standard DOT 3A480 cylinder of 45 to 68 kg (100 to 150 lb) capacity in chlorine service only. It is not designed to be used on liquid full cylinders.

Kit B contains tools and devices designed to stop and/or contain leaks in the standard DOT 106A500X chlorine ton container in chlorine service only. Not designed to be used on liquid full ton containers.

Kit C contains tools and devices designed to stop and/or contain leaks in the standard DOT 105A500W chlorine tank car and the DOT MC331 chlorine cargo tank in chlorine service only.



Assembly Mode



OPERATING PRINCIPLE – Leaks in chlorine shipping containers are stopped and/or contained by the application of the devices using the tools supplied in the kits. Procedures are provided in kit instructions.

PHYSICAL SPECIFICATIONS – Kits are contained in steel boxes which measure:

Kit A- 692 x 257 x 254 mm (27 1/4 x 10 1/8 x 10 in) (length x width x depth)
Kit B- 692 x 257 x 254 mm (27 1/4 x 10 1/8 x 10 in)
Kit C- 718 x 308 x 308 mm (28 1/4 x 12 1/8 x 12 1/8 in)

	Net Weight kg (lb)	Gross Weight kg (lb)
Kit A	45.4 (100)	47.6 (105)
Kit B	49.9 (110)	52.2 (115)
Kit C	79.8 (176)	86.2 (190)

OPERATING SPECIFICATIONS – Services the following chlorine containers:

Kit A	Kit B	Kit C
45.5 kg (100 lb) 68.0 kg (150 lb) cylinders	970 kg (2000 lb) container	tank car tank trucks

These three kits are not suitable for chlorine barge tanks. Manufacturer can fabricate chlorine barge kits if supplied with drawings.

STATUS OF DEVELOPMENT AND USAGE – In general use, these kits have been used with SO_2, phosgene, and hydrofluoric acid containers. A written release of responsibility from the purchaser is required if the kit(s) is used in any service other than chlorine.

PERFORMANCE – Not documented.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Indian Springs Mfg. Co., Inc.
2095 W. Genesee Road
P.O. Box 112
Baldwinsville, NY 13027
U.S.A.
Telephone (315) 635-6101
Contact: Mr. Maurice J. Ferguson

Information:

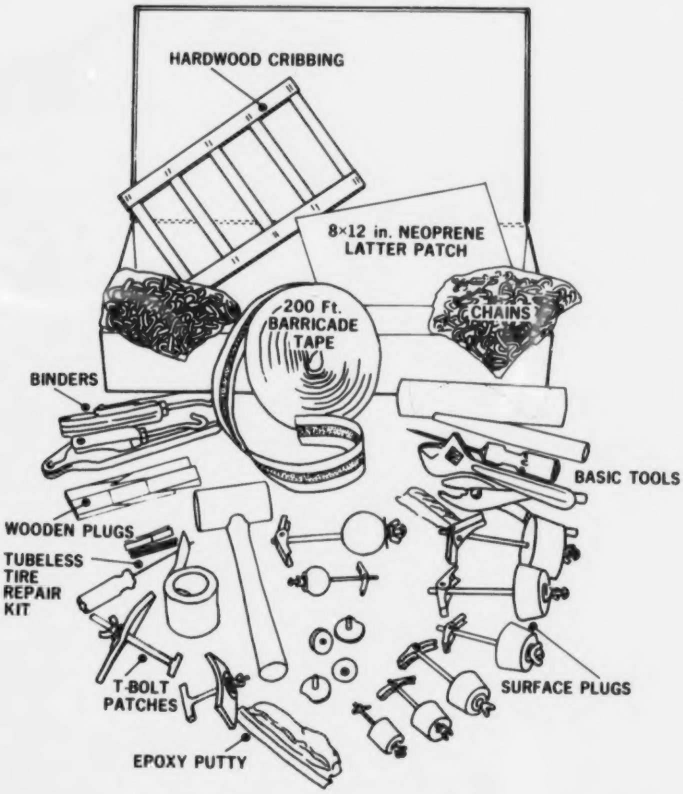
The Chlorine Institute Inc.
342 Madison Ave.
New York, NY 10173
U.S.A.
Telephone (212) 682-4324

OTHER DATA – Respirators and other personal protection equipment are not included in the kits but must be used when investigating and correcting chlorine leaks.

PRODUCT EDWARDS & CROMWELL EMERGENCY PACKAGE **No. 2**

APPLICABILITY	Gas	Liquid			Solid		
		Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*	*			

DESCRIPTION – A pre-packaged collection of commonly used components for emergency and temporary leak stoppage of liquid or bulk hazardous materials transported in common containers.



OPERATING PRINCIPLE – Punctures or cracks are sealed on a temporary basis using kit materials supplied.

PHYSICAL SPECIFICATIONS – Kits include sheet metal screws with neoprene compression seals, tubeless tire repair kit, lead wool, epoxy putty, hose repair tape, barricade tape, basic hand tools, 20.3 x 30.5 cm (8 x 12 in) neoprene ladder patch, two 6.1 m (20 ft) chains with "S" hooks and binders, T-bolt patches, assorted surface and wooden plugs.

OPERATING SPECIFICATIONS – Kits are designed for use only by experienced and trained personnel and only for temporary sealing. Application is possible to drums, cans, tank trucks and cars, storage tanks, etc.

STATUS OF DEVELOPMENT AND USAGE – Kits are commercially available composed of commonly used components.

PERFORMANCE – Not documented for spills of hazardous materials. Should be well suited for indicated use.

AVAILABILITY AND COMMERCIAL INFORMATION –

Edwards & Cromwell Manufacturing, Inc.
12016 Perkin Road
Baton Rouge, LA 70810
U.S.A.
Telephone (504) 292-3377

OTHER DATA – Product noted in Cashman, J.R. Hazardous Materials Newsletter (November 7, 1983). Package components are also referred to in Texas A & M hazardous material control course (1980).

PRODUCT EMERGENCY SAFETY KIT FOR VCM TANK CARS **No. 3**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
*		*				

applies to liquefied compressed vinyl chloride (see below)

DESCRIPTION – A protective housing arrangement and emergency safety kit for leaking valves on vinyl chloride monomer (VCM) tank cars. The emergency kit contains four sizes of cans, equipment to hold cans in position, and various tools.

OPERATING PRINCIPLE – The leaking fitting is covered with a can. A cross bar is placed over the can and a compression screw is used to force the can downward until the bottom edge of the can forms a seal around the manway cover.

PHYSICAL SPECIFICATIONS –

Can A	Can B	Can C	Can D
194 x 194 mm	184 x 192 mm	212 mm I.D.	76 mm I.D.

Cross Bar and Tie Bar dimensions not given in specifications.

Gasket to be approved by Compressed Gas Association.

Only intended for use on VCM cars with manway covers designed under CGA P-10-1980. This includes new 508 mm (20 in) or retrofitted 457 mm (18 in) manway covers.

OPERATING SPECIFICATIONS – Consult manufacturer.

STATUS OF DEVELOPMENT AND USAGE – Not documented for spills of vinyl chloride or other hazardous materials.

PERFORMANCE – Not documented.

AVAILABILITY AND COMMERCIAL INFORMATION –

Compressed Gas Association, Inc.
500 Fifth Avenue
New York, NY 10110
U.S.A.

OTHER DATA – None available.

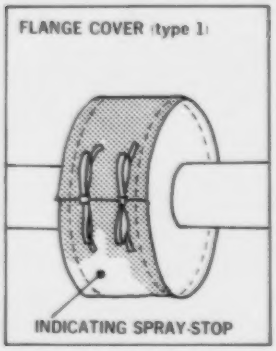
Reference: "Standard for Vinyl Chloride Monomer Tank Car Manway Cover and Protective Housing Arrangement and Emergency Safety Kit" 1980; Compressed Gas Association, Inc. Specification CGA P-10-1980.

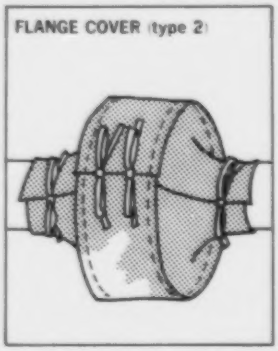
PRODUCT MILSHEFF SPRAY-STOP
VALVE AND FLANGE COVERS **No. 4**

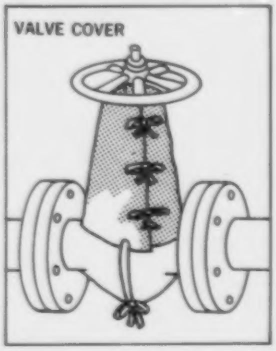
APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – Cover can be used as an enclosed barrier to deflect leakage (e.g., a mist or a stream) at joints or valves and contain the liquids in one specific area; consists of a woven-glass fabric and tie strings.







OPERATING PRINCIPLE – The cover is wrapped around the leaking area and secured in place with tie strings.

PHYSICAL SPECIFICATIONS – Fabric coated with chemical-resistant vinyl or teflon. Valve covers available in 11 sizes up to 653 mm (25.7 in) in height and 1270 mm (50 in) in circumference. Flange covers available for all ASA sizes from 13 mm (0.5 in) and up.

OPERATING SPECIFICATIONS –
Temperature Upper Limit:
Teflon (non-indicating) Spray-Stop: 260°C
Standard (non-indicating) Spray-Stop: 104°C
Resistant to acids, caustics and other industrial chemicals. Can be attached or removed quickly. Chemical compatibility with vinyl and teflon indicated.

STATUS OF DEVELOPMENT AND USAGE – In general use. Intended for a variety of substances.

PERFORMANCE – No documentation obtained.

AVAILABILITY AND COMMERCIAL INFORMATION – U.S. Patents: 2,601,840 and 2,708,896.

Manufacturer:
Slickbar, Inc.
250 Pequot Avenue
Southport, CT 06490
U.S.A.
Telephone (203) 255-2601
Mr. John Sullivan

Canadian Distributor:
Industrial Plastics Canada Ltd.
P.O. Box 93
Fort Erie, Ontario
L2A 5M6
Telephone (416) 871-0412
Mrs. B. Smith

Pricing – (effective February 28, 1983)
Costs for valve covers $14 to $350 (U.S.).
Costs for flange covers $15 to $225 (U.S.).

OTHER DATA – Safety Supply of Canada also distributes these specialized covers. Special application covers for pumps and other equipment are supplied by Slickbar, Inc. Also available are indicating spray-stop covers which give early warning of a leak by colour change and provide containment in the immediate area. Special high temperature flange covers in various sizes for primary steam lines and hot liquids up to 300°C supplied by Slickbar, Inc.

References: Manufacturer's Literature; personal communication, Mrs. B. Smith, Industrial Plastics Canada Ltd. (June 24, 1981); personal communication, Mr. J. Sullivan, Slickbar, Inc. (January 27, 1984).

PRODUCT NRC
TANTALUM PATCH KIT **No. 5**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – A plugging device which can be used to patch leaks of hazardous chemicals from glass-lined equipment. The patch kit consists of a tantalum slotted stud, hex nut, disc and teflon gaskets.

OPERATING PRINCIPLE – A hole is drilled and tapped in the leak area. The patch kit is placed on top of the leak with the stud entering the threaded hole. The stud and hex nut are tightened until a seal occurs between the patch kit and the surface material.

PHYSICAL SPECIFICATIONS –

Part No.	Patch Size
B2150-143-075	19 mm (3/4 in)
B2150-143-100	25.5 mm (1 in)
B2150-143-150	38 mm (1 1/2 in)
B2150-143-200	51 mm (2 in)
B2150-143-250	63.5 mm (2 1/2 in)
B2150-143-300	76 mm (3 in)
B2150-143-400	102 mm (4 in)
B2150-143-500	127 mm (5 in)
B2150-143-600	152 mm (6 in)

OPERATING SPECIFICATIONS – Resistant to corrosion by most organic and inorganic acids at temperatures up to 200°C except hydrofluoric acid, concentrated sulfuric acid and hot phosphoric acid. Alkalis (boiling) will corrode tantalum patch. Can be used in areas where large leaks are involved by acquiring larger size materials.

STATUS OF DEVELOPMENT AND USAGE – Item is commercially available. Usage has not been documented for spills of hazardous materials.

PERFORMANCE – No evaluation data obtained.

AVAILABILITY AND COMMERCIAL INFORMATION –

NRC Inc.
45 Industrial Place
Newton, MA 02164
U.S.A.
Telephone (617) 969-7690
Contact: Ms. S.R. Fernandez
Supervisor Sales Services

Cost – Ranges from $26.80 for 19 mm (3/4 in) size to $613.55 for 152 mm (6 in) size (May 1981).

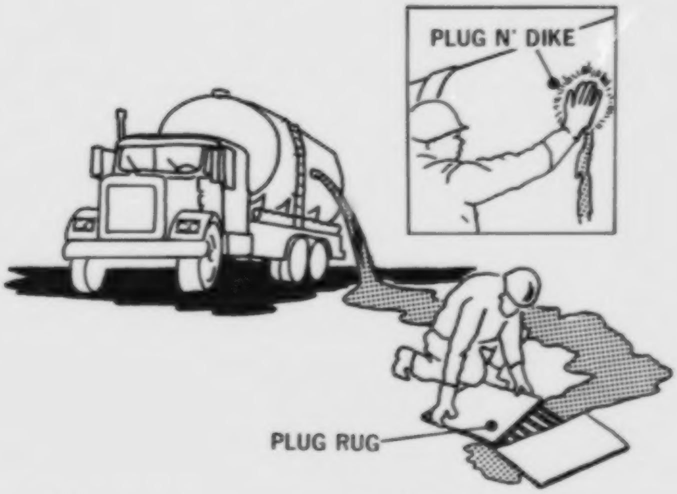
OTHER DATA – Also known as Norton tantalum patch kit.

References: Manufacturer's Literature; personal communication, Ms. S.R. Fernandez, NRC Inc., (May 19, 1981).

PRODUCT PLUG N' DIKE **No. 6**

APPLICABILITY	Gas	Liquid			Solid		
		Sol	Fl	Sk	Sol	Fl	Sk
		*	*	*			

DESCRIPTION – A granular material which when mixed with water forms a seal to control hazardous material spills. It is a combination of a high water-absorption, corn starch-polyacrylonitrile graft copolymer and a bentonite base.



OPERATING PRINCIPLE – The material, mixed with water, forms a sticky paste which adheres to dirty, greasy or rusty surfaces to plug leaks. It can also be used to build containment dikes to divert or contain spills, or plug storm sewers and drains.

PHYSICAL SPECIFICATIONS – Form: Granular or premixed paste (see also Other Data)
Density: Approximately 1041 kg/m^3 (65 lb/ft^3)
Unlimited shelf-life; not a skin-irritant

OPERATING SPECIFICATIONS – Can plug leaks under 1.8 m (6 ft) to 2.4 m (8 ft) head of liquid. Can plug leaks on dirty, greasy, or rusty surfaces and while material is flowing over it.

Mastic must be mixed with Plug N' Dike paste.

Will control nitric and phosphoric acids for about 30 minutes. Plug N' Dike will not control hydrogen peroxide.

STATUS OF DEVELOPMENT AND USAGE – Product is in general use and has undergone testing (see following).

PERFORMANCE – Laboratory results reported by AMTEST Inc. using three methods of application:

			Application Method		
Solvent	Concentration (%)	I	II	III	
Acetic Acid	99	-	+	NT	
Aqueous Ammonia	30 to 40		+	NT	NT
Formaldehyde	37	+	NT	NT	
Hexane	99	-	+	NT	
Hydrochloric Acid	37.9	-	+	NT	
Hydrofluoric Acid	24	+	NT	NT	
Methanol	99	-	-	+	
Methylene Chloride	99	-	+	NT	
Methyl Isobutyl Ketone	99	-	-	-	
Nitric Acid	70	-	-	-	
Sulphuric Acid	95 to 98		-	-	+
Sodium Hydroxide (Aqueous)	50	-	+	NT	
Toluene	99	-	+	NT	
Triethylamine	99	-	-	+	

+ positive result - negative result

NT: not tested under that method since it proved efficient with the previous method.
Method I: Dry dike sprayed with water to form thin seal on face of dike.
Method II: Slightly heavier application of water, using shovel to smear surface and seal it to pavement.
Method III: Water mixed into entire dike to form complete barrier.

Case histories include the temporary plugging of a jet fuel tanker involving a 15 cm (6 in) hole; stoppage of a leak from a 25 x 10 cm (10 x 4 in) tear along a seam in a tractor-trailer using a 61 cm (24 in) Plug Rug patch; and containment of a spill from ruptured drums of chemicals in a creek via the formation of a dike.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Construction Aids Technology, Inc.
812 102nd N.E., Burton Bldg.
Bellevue, WA 98004
U.S.A.
Telephone (206) 454-2034
Contact: Mr. Bill Griffin

Canadian Distributors:

Georgian Bay Fire & Safety Supplies Ltd.
P.O. Box 803
Owen Sound, Ontario
N4K 5W9
Telephone (519) 376-6120
Contact: Mr. Harold W. Bradley, President

Sanivan Inc.
1705 3e Avenue
Montreal, Quebec
H1B 5M9
Telephone (514) 353-9170
Contact: Mr. Pierre Richard

Cost ($ Cdn effective 1983):

Granular, in pail:	Premixed:
3.6 kg (8 lb) @ $24.98	400 g (14 oz) @ $15.00
10.9 kg (24 lb) @ $59.75	800 g (28 oz) @ $28.65
21.8 kg (48 lb) @ $106.50	

OTHER DATA – The company's products also include:

(1) Plug N' Patch Kits (Series 100 and Series 200) – An epoxy patch which is placed on the outside of the Plug N' Dike paste to prevent it from losing its adhesion because of drying or vibration. Both components used together provide a semi-permanent patch to keep the equipment in service.

Pricing (effective 1983): Series 100 (Super-fast): $41.65; Series 200 (Cure in air or underwater): $61.60

(2) Plug Rug – A fabric reinforced Plug N' Dike pad used to seal leaks and prevent spills from entering drains and storm sewers. For fuels as well as chemicals, including ammonia and acids.

Size and Cost (effective 1983): 41 x 61 cm (16 x 24 in): $52.50; 41 x 41 cm (16 x 16 in): $42.70; 20 x 20 cm (8 x 8 in): $18.10.

References: Manufacturer's Literature; Georgian Bay Fire and Safety Supplies Ltd., Owen Sound, Ontario.

CONCEPT: POLYMERIC ENCAPSULATION OF CONTAINERIZED HAZARDOUS MATERIALS

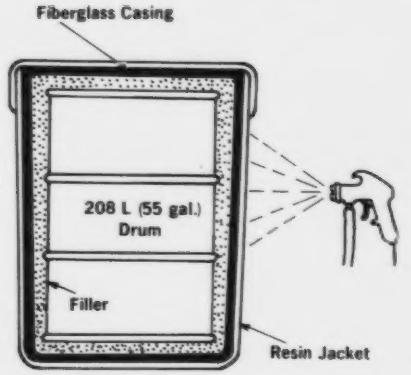
No. 7

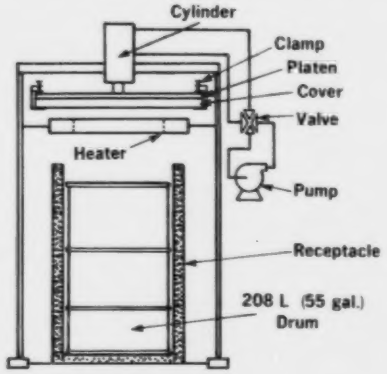
APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*	*	*	*

Note: Applicable to liquids or solids in ruptured containers.

DESCRIPTION A conceptual technique of securing corroded or leaking containers (208L (55 USG) steel drums) by spraying or brushing on polymeric compounds. The purpose of this encapsulation is to make the containers safe to transport and to deposit within a final landfill disposal site.





OPERATING PRINCIPLE – Three methods are proposed. One method consists of applying (by brush or spray) a layer of sealing material on the surface of the container followed by an outer jacket material to provide strength and protection against mechanical and chemical stress.

The combination of inner/outer layers is fiberglass-reinforced, thermosetting resin/water-based polyurethane.

A second method involves fusing powdered High Density Polyethylene (HDPE) to a thin casing of fiberglass-reinforced epoxy resin sprayed onto the surface of the ruptured container.

The third technique consists of welding 6.35 mm (1/4 in) polyethylene sheet to seal the openings of oversized polyethylene barrels in which corroded, leaking or damaged drums have been placed.

PHYSICAL SPECIFICATIONS – Materials investigated for the U.S. Environmental Protection Agency:

Inner Layer Material:	Spray-on chopped glass fiber is preferrable (used to form shower stalls, tubs, etc.). Cloth, mat and roving-type fiberglasses are more expensive and more difficult to apply.
Outer Jacket Material:	Atmospheric temperature curing polyurethane, such as Neorez R-960 cross-linked with CX-100.
Powdered High-Density:	Polyethylene (HDPE) used in commercial roto molding of polyethylene containers. Also possible are PE's used in extrusion and blow molding, low-pressure, linear PE and particulated scrap PE.

OPERATING SPECIFICATIONS - Spray-on fiberglass and resin, using commercially available spray equipment. Neorez R-960 polyurethane cures at ambient temperatures (longer curing times required at lower atmospheric temperatures). Safety equipment must be worn by personnel during formulation and fabrication of the polyurethane because of the toxicity of the cross-linking agent. Powdered polyethylene can be applied using standard roto molding techniques. Formation of thick coatings of the spray-on materials requires multiple applications. Polyolefins (including polyethylene) proved to be the best on a price/performance basis. Bitumens and asphaltics were less expensive than PE, but did not exhibit the engineering properties required for strength. A plastic welding apparatus similar to PE pipe welding devices was developed to weld commercially available 6.35 mm (1/4 in) sheet PE to equally available rotomolded overpack containers.

STATUS OF DEVELOPMENT AND USAGE – These techniques were investigated as a concept only for the U.S. Environmental Protection Agency by Environmental Protection Polymers, Inc. in 1981. Use of these methods in response to a hazardous material spill has not been documented.

PERFORMANCE – Application of polyurethanes to the surfaces of fiberglass/epoxide substrates effectively sealed porosity existing in the substrate, showing excellent resistance to hydrolysis. This method was concluded to be capable of retaining heavy metal salts, based on a sodium chloride test solution. The polyurethane jackets ruptured under heavy compression (greater than 20% of the height of the encapsulated container).

Fiberglass-backed HDPE encapsulated containers (102 mm (4 in) cylinders, 76.2 mm (3 in) in diameter) exhibited good retention performance of heavy metals (Ni, Cd, Hg, Cr, Zn, Cu, Sb, As, Se and Pb dissolved in hydrochloric acid) even when severely distorted vertically and laterally.

Overpack polyethylene drums (6.35 mm (1/4 in) thick) were found to be water tight overpacks when sealed with 6.35 mm (1/4 in) polyethylene sheet. The supply of sheet stock and overpack drums represents the largest cost of this encapsulation technique. In 1981, material costs to encapsulate 80 000 drums (representative of a large chemical dump site) were estimated to be $4.8 million (U.S.), with labour and capital costs at $228 000 and $45 000 (U.S.) per year, respectively.

AVAILABILITY AND COMMERCIAL INFORMATION – The referenced study was performed by:

Environmental Protection Polymers, Inc.
13434 South Prairie
Hawthorne, CA 90250
U.S.A.
Telephone (213) 970-9100

for

Municipal Environmental Research Laboratory
U.S. Environmental Protection Agency
Cincinnati, OH 45268
U.S.A.
Contact: Carlton C. Wiles, Project Officer

OTHER DATA – The application of spray-on/brush-on resins to containers leaking corrosives and/or solvents requires further investigation.

References: Lubowitz, H.R. and R.W., Telles, EPA Project Summary: Securing Containerized Hazardous Wastes by Encapsulation with Spray-On/Brush-On Resins, U.S. EPA Report EPA-600/S2-81-140, (NTIS No. PB81-231 284) (August, 1981).

Lubowitz, H.R. and R.W., Telles, EPA Project Summary: Securing Containerized Hazardous Wastes with Polyethylene Resins and Fiberglass Encapsulates, U.S. EPA Report EPA-600/S2-81-138, (NTIS No. PB81-232 449) (August, 1981).

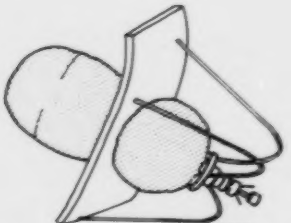
Lubowitz, H.R. R.W. Telles, S.L. Unger, and R.R. Phillips, EPA Project Summary: Securing Containerized Hazardous Wastes with Welded Polyethylene Encapsulates, U.S. EPA Report EPA-600/S2-81-139 (NTIS No. PB81-231-292) (August, 1981).

PROTOTYPE ROCKWELL EXTERNAL LEAK PLUGGING SYSTEM **No. 8**

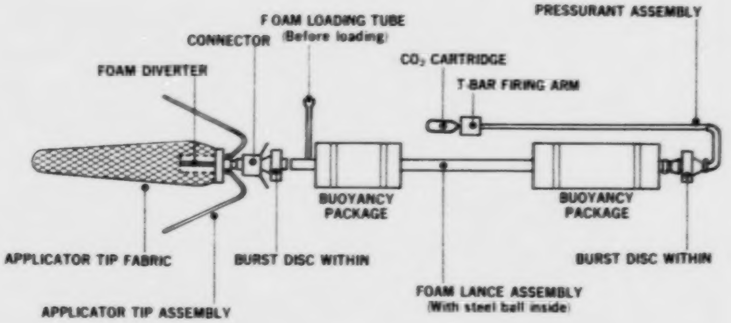
APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
*	*	*	*			

DESCRIPTION – Prototype device. A single-component polystyrene foam system used to plug holes in ruptured or damaged vessels (e.g., ships, tanks, etc.). Main components are a foam delivery system, the applicator tip assembly, and a buoyancy package. The foam delivery system consists of a foam-containing lance and a gas pressure assembly which provides the driving force for expulsion of the foam. The applicator tip directs the foam for plugging holes or ruptures, and consists of a hardware assembly and an outer tailored fabric.



APPLICATOR ACTIVATED



OPERATING PRINCIPLE – The applicator tip is positioned for optimum foam plug formation when the operator feels resistance to further passage of the applicator tip into the hole to be plugged. The firing mechanism is then activated, puncturing the gas cartridge to feed carbon dioxide gas into the lance. The gas pressure bursts a rupture disc at the rear of the lance and drives a chrome steel ball against the pressurized foam mix, breaking the front rupture disc and expelling the polystyrene foam from the lance. The polystyrene, previously dissolved in liquefied compressed gases, comes out of solution as the compressed gases vaporize at the lower ambient pressures. This results in the formation of a polystyrene matrix which expands and solidifies within the applicator tip fabric resulting in a rigid foam plug. When the steel ball strikes the front burst disc assembly, it forms a seal, preventing the pressurant gas from entering the foam plug.

PHYSICAL SPECIFICATIONS –

Pressurant Gas:	CO_2 gas from cartridge
Rupture Disc:	To break @ 2.07 x 10^3 kPa (300 psi)
Polystyrene Formulation:	Monsanto Corporation formula Solid polystyrene in methyl chloride Pneumatogen-compressed Freon 1331 gas
Applicator Tip Assembly:	Hardware covered by vinyl upholstery fabric or polyester sailcloth fabric Polymeric coatings for tip fabric may include - 3M Protective Coating 1706, Gacoflex Neoprene N-116, Gacoflex Hypalon H-2220, Nitrile Rubber and Fluorocarbon Rubber
Shelf-Life:	No weight loss after 1 year

OPERATING SPECIFICATIONS – Lower Temperature Limit: 0°C
Can be deployed for leaks in highway trucks and trailers, railroad cars, barges and other watercraft, stationary storage tanks and loading facilities, and pipelines. Can be deployed in areas with an angle as little as 20 degrees between the axis of the applicator and the surface of the tank at the hole. Can be deployed in areas with moderate heads, i.e., <2 m (6.6 ft) for highway tank trucks and <3 m (9.8 ft) for railway tank cars. Reusable system but not rechargeable in the field.

STATUS OF DEVELOPMENT AND USAGE – Engineering refinements to the plugging system have continued. The U.S. Coast Guard has been trained in its use; however, application to hazardous materials spills has not been documented.

PERFORMANCE – Tests of the prototype external leak plugger in an ocean environment were conducted by the U.S. Coast Guard from a motorized flat-top barge located in Fishers Island Sound off the Connecticut coast from Avery Point. Foam pluggings were made in circular hole sizes of 0.05, 0.10, 0.15 and 0.20 m, while target depths varied on the average from 0.65 to 3.6 m. Expulsion efficiencies averaged 91% and the time for expulsion in every case was only a few seconds (see tables for this entry).

AVAILABILITY AND COMMERCIAL INFORMATION – Patent pending.

Manufacturer:

Rockwell International
Environmental Monitoring and Services Centre
Environmental and Energy Systems Division
2421 West Hillcrest Drive
Newbury Park, CA 91320
U.S.A.
Telephone (805) 265-3248
Contact: Mr. R.W. Melvold

Cost: Approximately $1000 (May 1980)

OTHER DATA – The Rockwell External Leak Plugging System can be used above water if necessary by removing the buoyancy package. Work performed by Rockwell on the system has been sponsored by the U.S. Coast Guard and the U.S. EPA. With technical modifications to this system, it may be possible to plug holes or cracks as small as 0.025 m across and holes or cracks with wall thicknesses as large as 0.20 m. Further research is being carried out by Rockwell under the sponsorship of the U.S. EPA:

EPA Project Officer: Mr. I. Wilder
Telephone (201) 321-6635

Reference: Cook, R.L. and R.W. Melvold, Rockwell International: "Rockwell Leak Plugger. A Description and Guide for Determining Implementation", Proc. 1980 Nat. Conf. on Control of Hazardous Material Spills, pp. 316-321, (October, 1980).

PERFORMANCE DATA

Test Design-ation*	Lance Design-ation	Applicator Tip Fabric Modifications	Fabric Coating**	Temp. (°C)	Circular Hole Size (m)	Plug Description	Foam Weight (kg)	Expul-sion Effi-ciency (%)	Plug Density (kg/m^3)
LT1	A	Old; Seams, PVC	-	9	0.10	good	0.33	90	35
LT2	A	Old; Cap Seam, PVC; Slot	-	18	0.13	good	0.32	92	30
LT3	B	Old; Cap Seam, PVC; Flaps	-	18	0.13	not good, fabric hose clamp slipped	0.32	92	30
LT4	D	Old; Seams, PVC	-	19	0.10	good, exp. side seam	0.25	88	26
LT5	C	Old; Seams, PVC	-	19	0.13	very good, exposed side seam	0.30	90	29
LT6	C	Old; Cap Seam, PVC; Slot	-	20	1.10	good	0.32	-	-
LT7	D	Old; Cap Seam, PVC; Flaps	-	20	0.10	not good, ruptured on cap seam	0.29	-	-
LT8	B	Old; Seams, PVC	I	20	0.13	not good, ruptured on cap seam	0.36	-	-
LT9	A	Old; Cap Seam, PVC; Slot	-	20	0.10 x 0.20 (oval)	good, exposed cap seam	0.36	-	-
LT10***	A	Old; Cap Seam, PVC; Slot	I	21	0.13	good, exposed cap seam	0.32	-	-
LT11***	C	Old; Seams, PVC	II	21	0.10	good exposed cap seam and side seam	0.27	-	-
LT12	D	Old; Seams, PVC	III	21	0.10	adequate, med. spheres	0.25	-	-
LT13	A	New	I	20	0.13	very good	0.32	-	-
LT14	B	Old; Cap Seam PVC; Slot	I	20	0.10	good	0.32	92 92	29 30
LT15	C	New	I	20	0.10	good	0.32	90	30
LT16	D	Old; Cap Seam, PVC; Slot	I	20	0.15	good	0.32	92	29
LT17	B	New Rev.[a]	I	21	0.10	very good	0.30	93	27
LT18	A	New	I	21	0.10	very good	0.30	92	27
LT19	B	New Rev.	I	22	0.10	very good	0.31	93	30
LT20	C	New Rev.	III	22	0.10	very good	0.31	92	30
LT21	A	New Rev.	III	20	0.13	very good	0.29	90	27
LT22	D	New	I	20	0.15	good	0.26	90	22
LT23	F	New Rev.	I	20	0.15	very good	0.32	93	27
LT24	G	New Rev.	I	20	0.13	very good	0.31	91	27
LT25	H	New Rev.	III	20	0.10	very good	0.31	90	26
LT26	I	New Rev.	III	20	0.10	very good	0.31	90	29

[a] New Reversed: fabric tailored with vinyl side out and then turned inside out.

* tests conducted in lab. water trough using several polystyrene foam mixtures (same theoretical composition); wt. % of ingredients: polystyrene, 53.0; glass microballons, 1.0; Igepal C0970, 3.4; methyl chloride, 28.5; freon 1381, 14.1.

** coatings for application to outside surface. I-3M Protective Coating 1706; II-Gacoflex Neoprene N-116; and III-Gacoflex Hypalon H-2220.

*** Duckbill polyester sailcloth fabric used instead of usual vinyl upholstery fabric; polymeric coatings applied to applicator tip fabrics include: neoprene rubber resistant to refrigerants, high-aniline-point petroleum oils, mild acids and silicate ester lubricants; hypalon rubber resistant to salts, acids, alkalis and solvents; nitrile rubber resistant to petroleum oils and fluids, silicone greases and oils, di-ester base lubricants and ethylene glycol base fluids; and fluorocarbon rubber resistant to most petroleum oils di-ester base lubricants, silicone fluids and greases, halogenated hydrocarbons, selected phosphate ester fluids and acids.

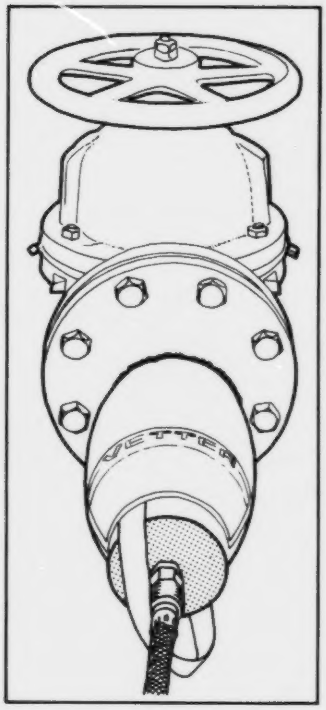
1.2 Containment on Land

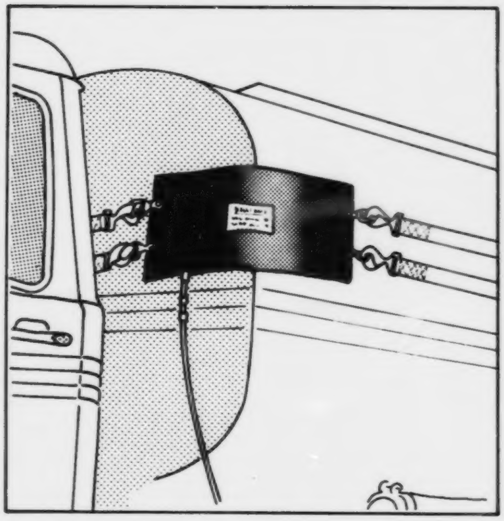
PRODUCT VETTER SEALING BAG **No. 9**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
*	*	*	*			

DESCRIPTION – The sealing bag provides temporary repair for damaged pipes, tanks, tank trucks and railway cars containing hazardous chemicals and can also be used for closing gully openings. The system consists of sealing bag, attachment belts, compressed air hose and pressure reducer, and safety unit.





OPERATING PRINCIPLE – The sealing bag is placed on or in the leaking area and secured with the attachment belts. The bag is inflated with compressed air until a seal occurs between the bag and the surface material.

PHYSICAL SPECIFICATIONS – **Leak-Sealing Bag (1.5 bar) System:**

Type	Width cm (in)	Length cm (in)	Applicable Pipe Diameter cm (in)
LB 5/20	20 (8)	90 (35)	5 to 20 (2 to 8)
LB 20/48	20 (8)	170 (67)	20 to 48 (8 to 19)

Constructed of neoprene outer layer, with inner layers of synthetic rubber and two layers of woven steel wire reinforcement, 20 mm (0.79 in) thick, and four swivel rings.

Attachment Belts:
Dimensions: 50 mm x 5 m (2 in x 16 ft) Ratchet belt is 2 m (6 1/2 ft) long constructed of Polyester with tensile strength of approximately 5000 kg
Compressed Air Hose: 10 mm (inside dia.) x 10.7 m (35 ft) long (1/2 in x 35 ft).
Compressed Air Pressure Reducer (200 bar): Adjustable to 16.8 kPa, 2 manometers, shut-off valve plus 1 m (3.3 ft) compressed air hose.
Safety Unit (1.5 bar): For connecting and deflating one leak sealing bag.
Weight of Complete System: Approximately 13 kg.
Accessories consist of extension belts, moss-rubber sealing plates and acid-proof protective cover.
Complete system sold as System 300; bags also known as Leak Bandages.

Pipe and Sewer Sealing Bag (1.5 bar) System:

Four types: 6 mm thick

Type	Size (dia. cm)	Inflated (dia. cm)	Length with Valve (cm)	Nominal Contents (L)	Weight (kg)
10/20	8.5	20	53	1.5	1.1
20/40	19.0	40	55	10.7	4.2
30/50	29.5	50	56	27.5	8.7
45/100	45.0	100	63	76.0	12.7

Constructed of multi-layer material with steel-reinforced nylon fabric.
Compressed Air Hose: 10 mm (inside dia.) x 10 m (long).
Compressed Air Pressure Reducer (200 bar): Adjustable to 16.8 kPa, 2 manometers, shut-off valve, 1 m compressed air hose.
Control Unit (1.5 bar): For connections and deflating two sealing bags.
Weight of Complete System: approximately 6.5 kg.
Accessories consist of safety unit (1.5 bar), compressed air cylinders in sizes of 4 L, 6 L, 10 L, special connectors, foot pump and inflating and safety hose.

OPERATING SPECIFICATIONS –

Leak Sealing Bag - Inflates via compressed air or hand pump. Can seal a surface of 500 x 300 mm with pressures up to 3.2 kPa in the sealing bag. Inflation time is under 5 seconds. Most connections have quick-action coupling. Ambient working temperature is 57°C (135°F).

Pipe Sealing Bags - Resistant to temperatures up to 100°C. Can plug openings from 10 to 100 cm. Inflation time ranges from 5 to 80 seconds. Most connections have quick-action coupling. Chemical compatibility same as for neoprene.

STATUS OF DEVELOPMENT AND USAGE – Products are commercially available. Usage has been reported for spills of hazardous materials.

PERFORMANCE – No documentation obtained for spills of hazardous materials. Refer to distributor regarding use of Vetter System at Mississauga, Ontario spill which occurred November 10, 1979.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:	Canadian Distributor:	**Cost:**	($Cdn)
Vetter Systems	Safety Supply Company (Canada)	Single valve control unit -	$ 206.38
605 Parkway View Drive	214 King Street East	Dual valve control unit -	$ 389.79
Pittsburgh, PA 15205	Toronto, Ontario	Sealing Bag Type LB 5/20 -	$ 441.40
U.S.A.	M5A 1J8	LB 20/48 -	$ 630.54
Telephone (412) 787-7970	Telephone (416) 292-8888	LB 10/20 -	$ 367.14
Contact: Mr. H. Metcalfe,		LB 20/40 -	$ 522.66
General Manager		LB 30/50 -	$ 808.66
		LB 45/100 -	$2339.54

OTHER DATA - See Section 5 also for information on Vetter Lifting Bags.

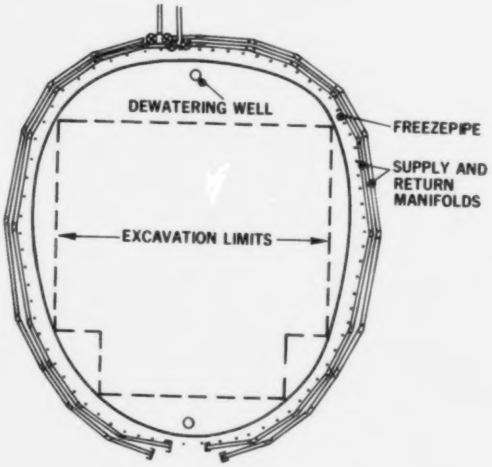
References: Manufacturer's Literature; personal communication Mr. J.S. Gordon, Safety Supply Company, (Canada), Ottawa, Ontario (January 30, 1984) - for prices.

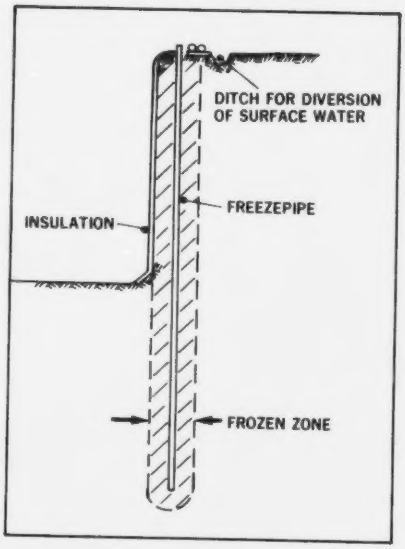
PRODUCT ARTIFICIAL GROUND FREEZING **No. 10**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – Concept only concerning spills. Artificial ground freezing is an established mining and civil engineering technique providing an impermeable barrier to groundwater flow. The approach has been applied in the construction of tunnels and cofferdams, and is now being considered for the control of hazardous material spills, where time allows implementation of the approach.





OPERATING PRINCIPLE – Holes drilled vertically or horizontally into the soil are spaced apart to obtain the desired closure freezing time and freezewall thickness. Freezepipes supplied with refrigerant from a manifold are then inserted into these holes. After freezing, soil retains the strength of soft rock by periodic re-refrigeration. Reinforcing rods can also be added before freezing to improve strength of barrier.

PHYSICAL SPECIFICATIONS – Ground freezing equipment varies with the application. The basic components include: drilling equipment, refrigeration unit (using Brine, Nitrogen), freezepipes, and supply and return manifold. At present, there are no systems designed specifically for hazardous materials spill control.

OPERATING SPECIFICATIONS – Effective use of artificial ground freezing requires prior knowledge of the direction and flow rate of groundwater, soil analysis (e.g., type, load-deformation of the frozen soil, moisture content), associated ground movements, as well as other hydrological considerations. Site exploration, laboratory testing, instrumentation and related data interpretation capability are required.

STATUS OF DEVELOPMENT AND USAGE – The approach is at present in the conceptual stage as a means to quickly (in less than 24 hours) implement ground freezing at a spill site.

PERFORMANCE – Recent civil engineering applications of ground freezing include:

- tunneling beneath railroad tracks in Washington, D.C.,
- construction of rapid transit tunnels beneath the Nihonbashi River in Tokyo, and
- construction of a sewer tunnel in Dusseldorf, West Germany.

Application to hazardous materials spills has not been documented.

AVAILABILITY AND COMMERCIAL INFORMATION –

Law Engineering Testing Company 7913 Westpark Drive P.O. Drawer QQ McLean, VA 22101 U.S.A. Telephone (703) 790-5700	Contact:	Mr. John S. Jones, Jr. Assistant Vice-President Chief Engineer

OTHER DATA – Application of artificial ground freezing to hazardous materials spill control is being pursued by Law Engineering Technology Company, McLean, VA, U.S.A., who are establishing a subsidiary, Geosystem Inc., to market and manage their technology (personal communication, J. Jones, December, 1983).

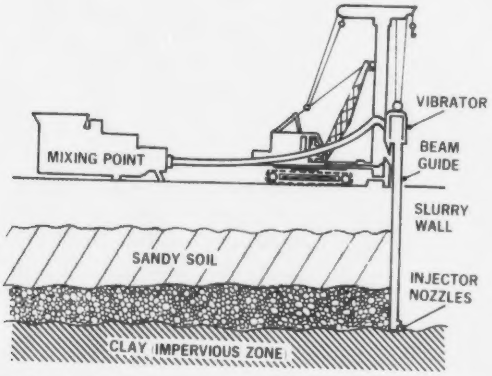
Reference: Jones, J.S. Jr., "State-of-the-Art Report: Engineering Practice in Artificial Ground Freezing," Engineering Geology, 18, pp. 313-326 (1981).

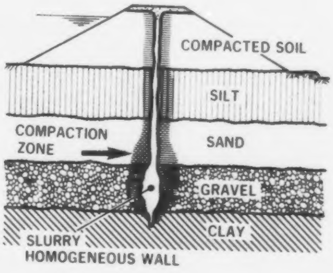
PRODUCT BENTONITE SOIL SEALING SYSTEMS No. 11

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – Sodium bentonite is a natural clay mineral with a molecular structure that permits water absorption up to 15 times its dry weight. Bentonite can be used to construct pollution seepage cut-off walls to prevent lateral migration of pollutants in soil and to underseal and/or surface cover effluent storage lagoons, landfills, and tailings storage ponds.





OPERATING PRINCIPLE – Cut-off walls are constructed using either a slurry trench technique or the vibrating beam technique. In a slurry trench, a bentonite slurry replaces the excavated soil, supporting the walls of the trench until it is backfilled with an impermeable material.

There are four principal slurry trench techniques:

1) soil, bentonite cut-off;
2) cement-bentonite cut-off;
3) plastic-concrete cut-off; and
4) concrete cut-off or diaphragm wall.

The vibrating beam method uses the pressure injection of slurry to construct a cut-off wall, eliminating the excavation of contaminated soil.

PHYSICAL SPECIFICATIONS – Specially formulated bentonite products are available as powder, with 75% to 85% passing 200 mesh (subject to customer specification), and in granular form. The latter is fine, free flowing material with an average sieve analysis of 65% to 85% passing between 40 and 160 mesh, and with less than 10% finer than 200 mesh.

OPERATING SPECIFICATIONS – Bentonite lowers soil permeability in direct proportion to the amount, type added, and uniformity of blending when mixed with soils. Powdered bentonite is usually applied under dry conditions between 10 to 20 kg/m^2 (2 to 4 lb/ft^2) of soil, then covered with 5 to 10 cm (2 to 4 in) of compact native soil. Bentonite is activated by wetting, which is a reversible process. It can be dried, reswelled and so restored to its preapplication condition.

STATUS OF DEVELOPMENT AND USAGE – Commercially available product requiring significant time for implementation and therefore of relevance to long-term projects. Manufacturer has provided documentation as regards application to hazardous materials spills (see following).

PERFORMANCE – Pollution Seepage Cut-Off Walls constructed using:

Vibrating Beam Technique:

10 m (33 ft) in depth around the Federal Pioneer Limited plant site in Regina, Saskatchewan to contain PCB spill (1980). Construction Time: 4 months. Three year performance data available: Ground Engineering Ltd., Regina.

Soil-bentonite Slurry Trench Technique:

Maximum depth: 7.2 m (23.6 ft). Premier Street Landfill Expansion, District of North Vancouver, B.C. (1982).

5.6 m (18 ft) depth. Construction Time: 4 months. Mercury Control Implementation, Thunder Creek Area, Moose Jaw, Saskatchewan (1981).

6000 m (19 685 ft) long, maximum depth: 8 m (26 ft). Tailings Pond Cut-Off, Potash Corporation of Saskatchewan, Cory Division Ltd., Saskatoon, Saskatchewan (1979).

213 m, (700 ft) trench 5.5 m (18 ft) deep, to cut off 5700 m^3 (1.5 million U.S. gal) of coal tar from Brodhead Creek, Stroudsburg, PA, $1 212 500 (U.S.) (1983).

Bentonite admixed with soil for undersealing:

Chloride waste storage pond. C-I-L Inc., Bécancour, Que. (1983).

Tailing storage, special waste storage, cobble ore storage, water storage, and fuel oil storage facilities. Uranium Mine and Mill. Key Lake, Sask. (1982).

Pickering Landfill Expansion. City of Toronto. (Ongoing since 1978).

Volclay Saline Seal-100 (bentonite clay) used to line a heavy metal waste sludges disposal area for CIBA-Geigy in Queensbury, NY. (1974 and Fall 1982): Overall Coefficient of Permeability of top liner was lower than State requirements (approximately 4×10^{-8} vs 1×10^{-7} cm/s).

AVAILABILITY AND COMMERCIAL INFORMATION –

Canadian Manufacturer:

Avonlea Mineral Industries Ltd.
204-4401 Albert Street
Regina, Sask.
S4S 6B6
Telephone (306) 584-2911

U.S. Manufacturers:

American Colloid Company
5100 Suffield Court
Skokie, IL 60077
U.S.A.
Telephone (312) 966-5720

NL Industries Inc.
Bariod Division
P.O. Box 1675
2404 Southwest Freeway
Houston, TX 77001
U.S.A.

Dresser Minerals
P.O. Box 6504
Houston, TX 77005
U.S.A.
Telephone (512) 972-2670

Federal Bentonite (Ashcono Chemical)
1002 Greenfield Road
Montgomery, IL 60538
U.S.A.
Telephone (312) 895-4142

International Minerals and Chemical
Corporation
Imcore Division
666 Garland Place
Des Plaines, IL 60016
U.S.A.
Telephone (312) 296-0600

Wyo-Ben Inc.
1242 North 28th Street
P.O. Box 1979
Billings, MT 59013
U.S.A.
Telephone (406) 252-6351 or
1-800-548-7055

Contractors:

Ground Slurry Systems Inc.
415 Seventh Avenue
Regina, Sask
S4N 4P1
Canada
Telephone (306) 569-9075
Contact: Mr. Doug Heenan

Carolina Slurry Systems
P.O. Box 186
Morrisville, NC 27560
U.S.A.
Telephone (919) 782-2573

Jebco Slurry Associates
Jebco Slurry Systems
1339 Chestnut Street
Philadelphia, PA 19107
U.S.A.
Telephone (215) 568-5707

Thatcher Engineering Corp.
Slurry Systems
7100 Industrial Avenue
Gray, IN 46406
U.S.A.
Telephone (219) 949-0561

Dutra Slurry Systems
P.O. Box 338
Rio Vista, CA 94571
U.S.A.
Telephone (707) 374-6339

Bermingham Slurry Systems
Wellington St. Marine Terminal
Hamilton, Ont.
L8L 4Z9
Canada
Telephone (416) 528-7924

OTHER DATA – For containment of concentrated chemical which would break down bentonite-based slurry cut-off wall, ASPEMIX, a slurry formulated using asphalt emulsions has been developed by Slurry systems, a division of Thatcher Engineering Corp.

Example: Pollution seepage control barrier constructed (using a vibrating beam technique) around a pond containing waste pesticides in California and a pond containing waste chemicals from a chemical recovery facility in Michigan.

References: Ground Engineering Ltd.
415 Seventh Avenue
Regina, Saskatchewan
S4N 4P1
Canada
Telephone (306) 569-8561
Contact: Mr. Paul Kozicki

"Great Wall of Stroudsburg", Waste Age, pp. 94, 96 (April, 1983).
Bentonite admixed with soil for undersealing:

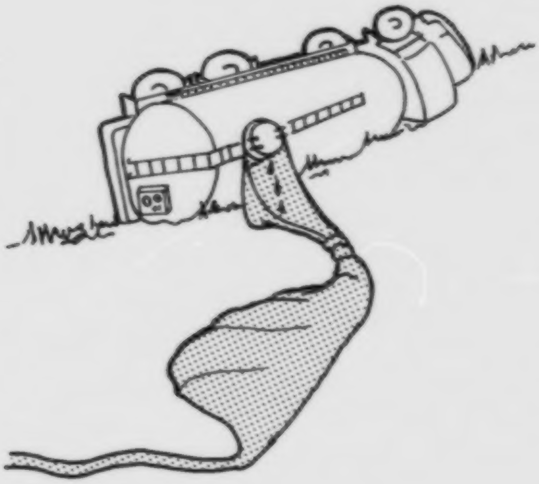
CIBA-Geigy File B-D-7, "CIBA-Geigy Industrial Landfill, Queensbury, NY" (1982).

PROTOTYPE CAPTURE AND CONTAINMENT BAG **No. 12**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – Prototype Device. A lightweight, portable bag for containing and providing temporary storage of hazardous spills from ruptured tank trucks and railroad cars.



OPERATING PRINCIPLE – The bag is positioned at the leaking container and raised to its ultimate point of application by tie lines. The large apron of the bag is secured around the leaking port or valve in a drawstring fashion using a cord fitted through grommets on the apron. The hazardous liquid can be transferred from the bag to a larger container by a built-in transfer line or contained in several bags connected in series.

PHYSICAL SPECIFICATIONS – A double-bag construction was selected for the prototype from among several polyethylene constructions tested. Typical construction includes:

Inner Bag:	Clear polyethylene film with continuously-heat-sealed seams 6 mil thick.
Outer Bag:	Close-weaved fibre-reinforced polyethylene film. Sewn seams, coated with polyethylene tape (9 mil thick).

Both bags are the same size, approximately 6.1 m long by 2.4 m wide (20 x 8 ft), with a 3 m (10 ft) apron at the opening and a 10 cm (4 in) transfer tube, 9.1 m (30 ft) long, at the other end.

Design capacity: 3785 L (1000 U.S. gal)
Tare Weight: approximately 7.3 kg (16 lb)
Storage Volume: less than 0.05 m^3 (2 ft^3)

OPERATING SPECIFICATIONS – Easily transported by one man. Deployed by two men (safety equipment recommended).

STATUS OF DEVELOPMENT AND USAGE – Prototype bags are available to selected parties for trial use through JRB Associates (see following).

PERFORMANCE – MSA Research Corporation, developer of the bag, simulated a railcar spill accident with water leaking at 19 to 280 L/s (5 to 15 U.S. GPM) from a top hatch. Two men wearing safety equipment (chemical resistant clothing, respirators) attached the bag to the hatch in one attempt. A second bag was connected to the transfer hose of the first bag to increase the total capacity of the system (more than 3800 L (1000 U.S. gal)). No leaks were evident in either bag.

AVAILABILITY AND COMMERCIAL INFORMATION – Design and development work conducted by:

MSA Research Corporation
Evans City, PA 16033
U.S.A.
Contact: Mr. Mervin D. Marshall
Telephone: (412)538-3510

on behalf of:

Mr. John E. Brugger
Oil and Hazardous Materials Spill Branch
Municipal Environmental Research Laboratory
Office of Research and Development
U.S. Environmental Protection Agency
Edison, NJ 08837
U.S.A.

Commercial Marketing:

JRB Associates
8400 Westpark Drive
McLean, VA 22102
U.S.A.

Telephone (703) 821-4600
Contact: Mr. Mark Evans
Waste Management Department

Cost – Information sent September 1983 included 1981 estimates of $50 to $200 (U.S.) per bag depending upon production rates.

OTHER DATA – The nature of the leak and positioning of the bag will largely determine the effectiveness of this device. The circumstances of the spill will therefore have a significant bearing on its suitability.

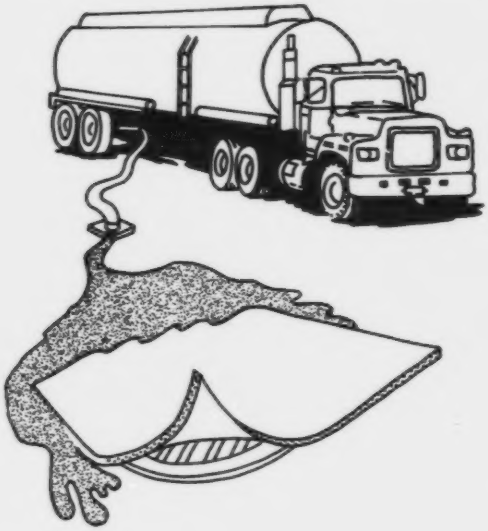
Reference: Mervin D. Marshall. MSA Research Corporation, Evans City, PA, U.S.A. "Design, Fabrication and Demonstration of Systems to Protect Ground Water from Hazardous Material Spills on Land", Contract No. 68-03-2507 to U.S. Environmental Protection Agency (October, 1982).

PRODUCT CLARK SPILSTOPPER MAT **No. 13**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – Specially engineered mat, designed to seal off gravity flow of hazardous materials into openings. The mat is a custom-formulated core elastomer containing polyurethane.



OPERATING PRINCIPLE – The spilstopper mat can be used as a protective cover for drains, grates, and manholes, whether on gravel, sand, grass, asphalt or concrete pavement.

PHYSICAL SPECIFICATIONS – Fabric is made of polyurethane rubber and elastomer.

Colour: High Visibility Orange
Weight: Approximately 11.0 kg/m^2 (2.25 lb/ft^2)
Thickness: 13 mm (1/2 in)
Sizes: Standard: 610 x 610 mm (24 x 24 in) Custom: up to 1067 mm (42 in) wide, any length
762 x 762 mm (30 x 30 in)
914 x 914 mm (36 x 36 in)
1067 x 1067 mm (42 x 42 in)

OPERATING SPECIFICATIONS –

Temperature Stability: stable between -29°C and 82°C (-20°F to 180°F).

Can be stretched to nearly twice its length and still recover completely. Not damaged by pedestrian traffic. Flexible and will conform to nearly any shape. Lightweight; stored on trucks or on-site.

Inert to water, petroleum products and most caustics. Impermeable to fluids.
Discolouration may be caused by extended exposure to ultraviolet radiation.
Recommended use during fuelling and high risk pollutant handling operations.
Can be washed with non-abrasive detergents or petroleum solvent cleaners.
Should be stored inside shaded compartment when not in use.
Recommended minimum size is 102 mm (4 in) larger than outside of grate.

Compatible for use with:

- Acetaldehyde (vapours)
- Acetone (vapours)
- Acrylonitrile
- Aluminum Salts (vapours)
- Ammonia
- Animal Oils
- Barium Salts
- Benzene
- Benzyl Alcohol
- Boric Acid Solutions
- 1,3 - Butadiene
- Butane
- Butanols
- Butyraldehydes
- Butylene (vapours)
- Calcium Salts
- Carbon Dioxide
- Chlorine (vapours)
- Chloroform
- Chlorothane VG
- Copper Salts
- Cresol
- Cumene
- Cyclohexane (vapours)
- * Cyclohexanone
- Epichlorohydrin
- Ethylbenzene
- Ethyl Chloride (vapours)
- * Tetrahydrafuron (THF)
- Toluene
- Triethylamine
- Tropylene Glycol
- Turpentine
- 2-Ethylhexanol
- Ethylene Oxide (vapours)
- Formaldehyde
- Freon
- Gasoline
- Glycerine
- Glycol Ether
- N-Hexane
- Hydrochloric Acid (Med. Conc.)
- Hydrogen Peroxide
- Hydrogen Sulphide (vapours)
- Isopropyl Alcohol
- Kerosene
- Linseed Oil
- Maleic Anhydride
- Methylene Chloride
- Methyl Ethyl Ketone
- Methyl Isobutyl Carbinol
- Methyl Isobutyl Ketone
- Methyl Methacrylate
- Naphtha
- Nitrogen Oxides
- Oil, Mineral and Vegetable
- Phenol
- Propylene (vapours)
- Sodium
- Styrene
- Sulphuric Acid (Med. Conc.)
- Urea
- Uric Acid
- Vinyl Acetate
- Vinyl Chloride
- Water
- Xylenes

* suitable for once-only use; outer material destroyed

STATUS OF DEVELOPMENT AND USAGE – Commercially available product in general use.

PERFORMANCE – Documentation on hazardous materials spills was not obtained.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Clark Products Company
916 West 25th Street
Norfolk, VA 23517
U.S.A.
Telephone (804) 625-5917
Contact: Mr. Stephen E. Clark

Cost (effective November 1, 1983 $ U.S.):

Model	Size - Square	1	10 or more
SS 242	610 mm (24 in)	$165	$140
SS 30	762 mm (30 in)	$188	$159
SS 36	914 mm (36 in)	$220	$187
SS 42	1 067 mm (42 in)	$300	$255

OTHER DATA – Manufacturer provides chemical compatibility list as a guide only and suggests pre-use trials due to diversity in composition of substances shipped.

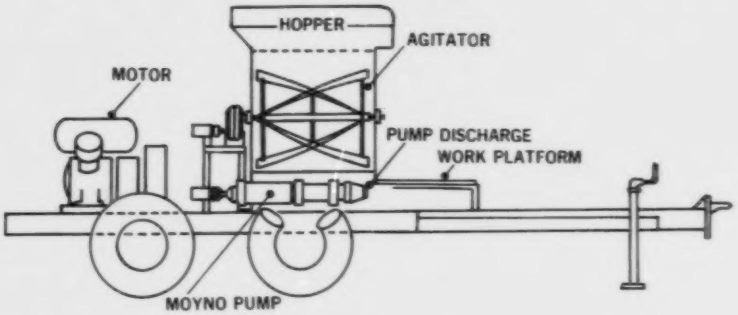
References: Manufacturer's Literature; personal communication, Mr. S.E. Clark, Clark Products Company, January 26, 1982; updated October 6, 1983; updated February 7, 1984; Noyes Data Corporation, New Jersey, Hazardous Chemical Spill Cleanup, pp. 40-49, 67-70 (1979).

PROTOTYPE FOAMED CONCRETE BARRIER SYSTEM **No. 14**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – Prototype System. A trailer-mounted, batch-mixing system for the production of foamed concrete, chemically-resistant containment dikes and free-form structures to divert the flow of low velocity streams. A barrier can be formed quickly on many different surfaces.



OPERATING PRINCIPLE – A silicate solution is injected into a slurry of cement and preformed foam at the exit of a shotcrete nozzle. The resulting chemical reaction reduces the time required for the concrete to set, yielding a rigid, free-standing wall of foamed concrete.

PHYSICAL SPECIFICATIONS – Primary "off-the-shelf" components of this trailer-mounted unit include:

Mixer for blending cement-water slurry (similar to MSA P/N A91959, 400 no. hopper with MSA P/N 379 689 agitator)

Air compressor (Ingersoll-Rand Type 30, Model 71T2XGT)

Gas Engine (Wisconsin Model V465D)

Pumps: Slurry (Moyno 3L4, P/N 68572)
Silicate Proportioning (Viking HL 124S)
Foam Concentrate (Viking HL156)
Foam Tank
Foam Gun

OPERATING SPECIFICATIONS –

Approximately 1.4 m^3 (50 ft^3) of foamed concrete at 720 kg/m^3 (45 lb/ft^3) can be produced per batch by two men within 30 minutes of delivery to the site (repeat cycles would require approximately 25 minutes).

Raw materials for one batch include:
10 bags of Type 1 Portland cement (427 kg (940 lb))
114 L (30 U.S. gal) of 50% sodium silicate solution
1.4 L (1.5 qt) of MSA detergent-based foam concentrate
270 kg (600 lb) or water
(Materials for one batch would be transported on the unit.)

Raw materials for 3 batches would weigh approximately 2220 kg (4900 lb) and require 817 kg (1800 lb) of water.
3 batches (4.2 m^3 (150 ft^3)) of foamed concrete could build a barrier:

	0.6 x 0.6 x 11.6 m	(2 x 2 x 38 ft)
or	0.46 x 0.6 x 15.2 m	(1.5 x 2 x 50 ft)
or	0.46 x 0.9 x 10 m	(1.5 x 3 x 33 ft)

in approximately 80 minutes.

STATUS OF DEVELOPMENT AND USAGE – Foamed concrete technology is well developed and is commonly used for fills, thermal insulation, and roof decks. Usage of this approach for spills of hazardous materials has not been documented.

PERFORMANCE – Type of substrate is not critical. Successful tests have been made on clay, shale, chipped limestone, grass and weed-covered ground.

Methanol, 1,1,1-trichloroethane, phenol, acetone cyanohydrin and acrylonitrile do not appear to affect the gel set action.

The ability to construct a dike in a moving stream appears to be a function of the rate of development of the head of liquid being contained. A 33 cm (13 in) high, 23 cm (9 in) thick dike impounded water flowing at 58 L/min (15 U.S. GPM) to a head of 25 cm (10 in) in 22.5 minutes while a similar dike failed when the head of water reached 25 cm (10 in) in 4 minutes.

Freezing point lowering additives (e.g., aliphatic or polyhydric alcohols, $CaCl_2$, NaCl) in the slurry for operation during sub-freezing conditions retarded the setting time of the concrete or reduced the quality of the foam.

AVAILABILITY AND COMMERCIAL INFORMATION – Design and development work completed by:

MSA Research Corporation
Evans City, PA 16033
U.S.A.
Telephone (412) 538-3410
Contact: J.V. Friel
R.H. Hiltz
M.D. Marshall

for: Ira Wilder, Project Officer
U.S. Environmental Protection Agency
Edison Water Quality Research
Laboratory, NERC
Edison, NJ 08817
U.S.A.

OTHER DATA – For additional information, also consult the following reference:

J.V. Friel et al., Control of Hazardous Chemical Spills by Physical Barriers, Project 15 090 HGP, Contract 68-01-0100, Environmental Protection Agency, Edison Water Quality Research Laboratory, NERC, Edison, NJ, 08817 U.S.A. Report EPA-R2-73-185 (March, 1973).

JRB Associates was contracted to market the foamed concrete system for the U.S. EPA. For more information, contact:

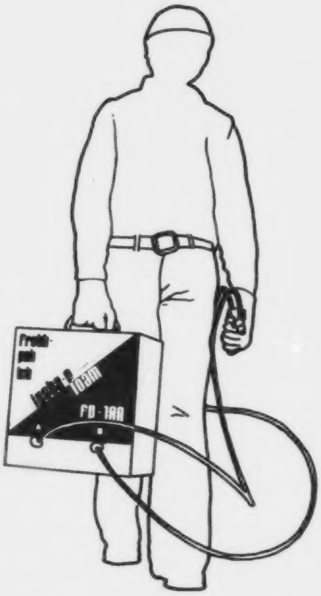
Mr. Mark Evans
Waste Management Department
JRB Associates
8400 Westpark Drive
McLean, VA 22102
U.S.A.
Telephone (703) 734-4381 or 821-4600

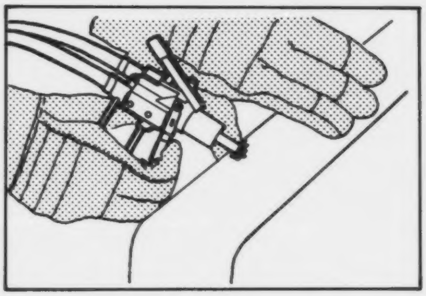
PRODUCT FROTH-PAK PORTABLE FOAM SYSTEM **No. 15**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – A portable system which generates a polyurethane foam to dike or contain spills of hazardous chemicals on dry ground surfaces. The two components of the foam system are contained in two cylinders in a common carton, with an applicator hose and gun.





OPERATING PRINCIPLE – As the gun trigger is activated, the chemicals are released under pressure and mixed at the gun tip, producing a foam which is applied to the spill area.

PHYSICAL SPECIFICATIONS – Available in small, medium and large sizes, various models (see under Price Schedule).

Weight of medium-size system: 16.3 kg (36 lb)
Portable self-contained unit
Dimensions of medium-size unit: 406 x 406 x 203 mm (16 x 16 x 18 in) high x wide x deep.

Cylinder chemicals: Polymeric isocyanate and polyol which contains amines and fluorocarbons

Accessories: Nozzles
- Model NR for pouring
- Model NS for spraying
- Model GMC for spraying at 360° right angles

Extenders
- Model GNE Extender kit with 3.2 mm diameter tubing
- Model NE-1/4 for caulking (for use with NS nozzle)
- Model NE-3/4 for caulking (for use with NS nozzle)

Gun-hose assemblies
- Model GHA-71/2 is 2.3 m (7 1/2 ft) long
- Model GHA-15 is 4.6 m (15 ft) long
- Model GHA-30 is 9.1 m (30 ft) long

OPERATING SPECIFICATIONS –

Approximately 0.34 m^3 of foam can be delivered at 25°C. System dispenses at a rate of approximately 5.4 kg/min and takes about 2.5 min to empty the containers.

Not suitable for blocking a flowing stream and has poor adhesion on wet or vegetated surfaces.

Expands to five times its volume and is tack-free in less than 60 seconds.

Self-sufficient and requires no outside energy source.

May constitute a fire hazard if improperly used or installed.

Optimally applied at 23.9°C (75°F); lower temperature application limit is 1.7°C (35°F); operating limits are -162°C to 121°C (-260° to 250°F).

The following is a list of chemicals that polyurethane foam may be applied to (Noyes):

Acetaldehyde (vapour)
Acetone (vapour)
1,3-Butadiene
Benzene
Ethylene Oxide (vapour)
Hydrogen Sulphide (vapour)
Propylene (vapour)
Vinyl Chloride
2-Ethylhexanol
Styrene
Xylenes
Turpentine
Vinyl Acetate
Ethylbenzene
Cumene
Butanols
Methyl Methacrylate
Butyl Aldehydes
Isopropyl Alcohol
Butylene (vapour)
Cyclohexane (vapour)
Ethyl Chloride (vapour)
Chlorine (vapour)
Cresol
Chloroform
Aluminum Chloride (vapour)
Methyl Ethyl Ketone
Methyl Isobutyl Carbinol
Methyl Isolbutyl Ketone
Acrylonitrile
Maleic Anhydride
Toluene
n-Hexane
Urea
Epichlorohydrin

STATUS OF DEVELOPMENT AND USAGE – Commercial product designed and marketed primarily for construction/insulation applications. Use not documented for spills of hazardous materials.

PERFORMANCE –

Density (ASTM 1622):
Spray Density 38.4 ± 1.6 kg/m^3
Poured Density 36.0 ± 1.6 kg/m^3
Molded Density 38.4 ± 1.6 kg/m^3

Smoke Density: 450

Compressive Strength (ASTM 1621):		
Parallel at 10%	241	kPa
Perpendicular at 10%	107	kPa
Modulus - Parallel	6 495	kPa
Modulus - Perpendicular	2 620	kPa

Tensile Strength (ASTM 1623):		
Parallel at 10%	334	kPa
Perpendicular	176	kPa

Shear Strength:

Parallel	150	kPa
Perpendicular	117	kPa
Modulus - Parallel	1 607	kPa
- Perpendicular	1 117	kPa

Water Vapour Transmission 2.5×10^{-12} kp/Pa.s.m^2
Closed Cell Constant (ASTM D-2856): 90%+
Water Absorption (ASTM 2842): 4.7%
Dimensional Stability (ASTM 2126):
  -0.4% Volume Change, -40°C, 2 weeks
  +2.1% Volume Change, 70°C, 100% humidity, 2 weeks

Tests have shown that once blown and rigid, the foam was unaffected by acrylonitrile, phenol, chlorine, ammonia and acetone. Methyl alcohol, however, soaked into the foam, destroying its effectiveness in blocking the material.

AVAILABILITY AND COMMERCIAL INFORMATION –

U.S. Manufacturer:

Insta-Foam Products, Inc.
1500 Cedarwood Drive
Joliet, IL 60435
U.S.A.
Contact: Mr. Kovarik
Telephone (800) 435-9359
(312) 621-1102
or (815) 741-6800
Telex 72-3415

Canadian Representative:

Insta-Foam Products, Inc.
P.O. Box 21
Etobicoke, Ontario
M9C 4V2
Contact: Mr. P. Bludd or Mrs. V. Picard
Telephone (416) 622-6844

Local distributors in Canada and the U.S. retail the company's products.

Price Schedule ($ Cdn effective October 3, 1983):

Small Froth Pak	$ 28.00
Medium Froth Pak	$378.42
Large Froth Pak	$808.04

These are suggested list prices for standard foam kits. Various kit models (e.g. slow rise, low density, high compression, etc.) are also available as are refills, kit accessories, nozzles and miscellaneous items.

OTHER DATA – Froth-Pak was formerly marketed as the Portafoam system. Lusta-Foam Products, Inc. also now manufactures a one-component foam sealant kit known as Insta-Seal designed primarily for the prevention of air infiltration as well as an acoustical sealant.

References: Manufacturer's literature; personal communication, Mr. J. Palumbo and Mr. M. McDonald, Insta-Foam Products Inc. (February 3 and 5, 1982); Noyes Data Corporation, New Jersey, Hazardous Chemical Spill Cleanup, pp. 40 to 49, 67 to 70 (1979); Friel, J.V. et al., Control of Hazardous Chemical Spills by Physical Barriers, EPA-R2-73-185 (PB-221-493) (March, 1973).

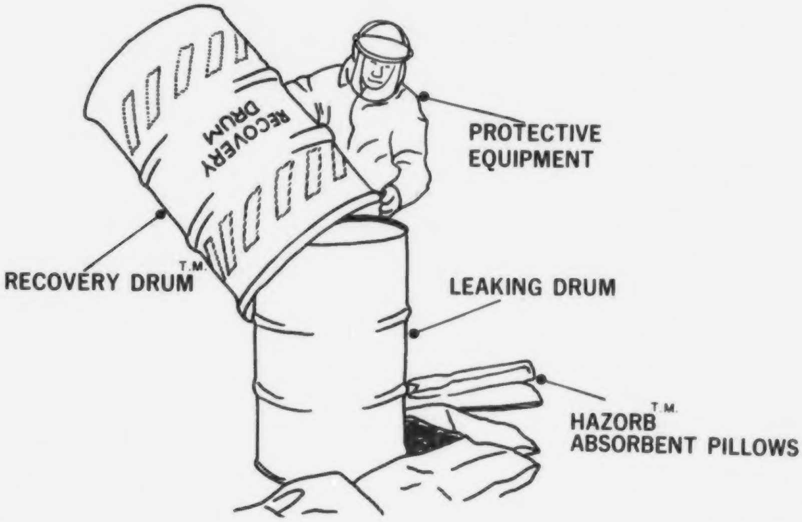
PRODUCT GEORGE MANN CHEMERGENCY KIT **No. 16**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

Note: Applicable to leaks and spills of liquids on land.

DESCRIPTION – A kit of absorbent, personal safety equipment and an overpack steel drum for cleaning up small volume liquid spills, particularly from drums of 208 L (55 U.S. gal) or less.



OPERATING PRINCIPLE – All components of the kit are removed from the overpack drum, the protective overalls put on, and the absorbent pillows applied to the spilled liquid. The damaged container is sealed in the overpack drum and the absorbent disposed of properly.

PHYSICAL SPECIFICATIONS – Inside a 322 L (85 U.S. gal) overpack RECOVERY DRUM™ (see under "BASCO SALVAGE DRUM" in this survey) are contained:

15 HAZORB (see "HAZORB" in this survey) Absorbent Pillows.
Coveralls, hood and shoe covers made of chemical-resistant TYVEK (DuPont). Goggles and full face shield. Protective nitrile gloves. Polyethylene scoop. Drum wrench and faucet. Assorted D.O.T. (U.S.A.) hazard labels.

OPERATING SPECIFICATIONS – Not applicable.

STATUS OF DEVELOPMENT AND USAGE – Commercially available for use in the chemical process industry and by electroplaters, truckers and fire service personnel.

PERFORMANCE – Documented use for response to hazardous chemical spills was not readily available.

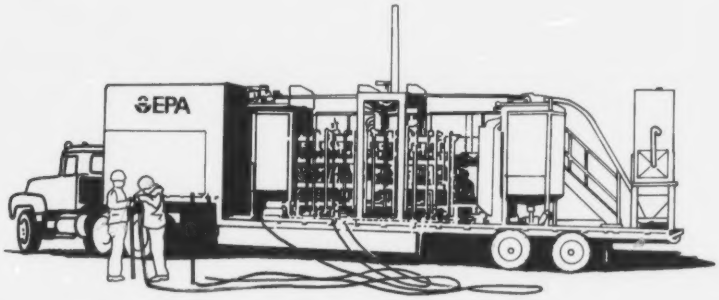
AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:
George Mann and Company, Inc.
Harborside Blvd.
P.O. Box 9066
Providence, RI 02940, U.S.A.
Telephone (401) 781-5600
1-800-556-2426

PROTOTYPE IN-SITU CONTAINMENT AND TREATMENT SYSTEM **No. 17**

APPLICABILITY	Gas	Liquid			Solid		
		Sol	Fl	Sk	Sol	Fl	Sk
		*	*	*			

DESCRIPTION – Prototype. An underground envelope is created to surround and contain a spill and neutralizing agents applied directly to it. The system consists of all required pumps, injectors, etc., housed on one 13.1 m trailer.



OPERATING PRINCIPLE – A grout "wall" is created by direct injection of the grout mixture into the soil around the spill area. Other injectors are used to apply in-situ spill neutralizing agents.

PHYSICAL SPECIFICATIONS –

Trailer: Length, 13.1 m; Weight, 25 000 kg
Tanks: 2460 L, chemical-resistant lining
Grout Pumps: Progressive cavity, 0.06 to 0.6 L/s, 552 kPa, steel construction
Chemical Pumps: Air diaphragm, 0.0 to 1.3 L/s, 552 kPa, Hastelloy C construction
Mixers: 200 x 10^{-6} m^2/s, 1 1/2 hp motors, double rubber-coated impeller
Generator: 135 kW diesel-electric, muffler
Air Compressor: 3.4 m^3/min at 689 kPa
Hosing: 38 mm I.D., 689 kPa, chemical resistant, quick disconnect
Injectors: 1.5 m, 19 mm diameter, heavy duty black steel pipe/threaded and coupled, 16 in total
Retraction Device: Retract 2 injectors each on angle and straight; moves at 0.3 m/min.

OPERATING SPECIFICATIONS – Designed to contain and treat a spill volume of 40 000 L

Suggested applications:

- controlling landfill leachate migration;
- nutrient injection to enhance degradation of spilled or contaminating materials;
- containment of spills for treatment with other equipment; and
- treatment of leachate contaminated soil around disposal sites.

STATUS OF DEVELOPMENT AND USAGE – Laboratory testing has been conducted, usage has not been documented for spills of hazardous materials.

PERFORMANCE – Testing for the EPA was conducted to determine any operational difficulties. It was found that starting of the diesel-electric generator was difficult. It was noted that the grout formed a spherical pattern around the injector point.

Laboratory-scale tests on inplace decontamination performed for the U.S. EPA determined a removal rate of between 58.3% and 100% for the two test contaminants, copper sulphate and sodium hypochlorite in varying soil media and loading concentrations.

AVAILABILITY AND COMMERCIAL INFORMATION – A prototype unit was delivered to the U.S. EPA and underwent "shakedown" tests in May 1980.

Municipal Environmental Research Laboratory

U.S. EPA
Edison, NJ 08817
U.S.A.
Telephone (201) 321-6633
Contact: Mr. M.D. Royer

OTHER DATA – Since the 1980 tests, an advanced prototype unit has been developed with an upgraded and refurbished pumping system, electronics, etc. "Shakedown" of this system was scheduled for June or July of 1984.

References: Personal communication, Mr. M.D. Royer, U.S. EPA (February 14, 1984).

Huibregtse, K.R. and Kastman, K.H., Rexnord, Inc.: "Construction and Preliminary Testing of a System to Protect Ground Waters from Hazardous Spills", Proc. 1980 Nat. Conf. on Control of Hazardous Material Spills, pp. 77-81 (1980).

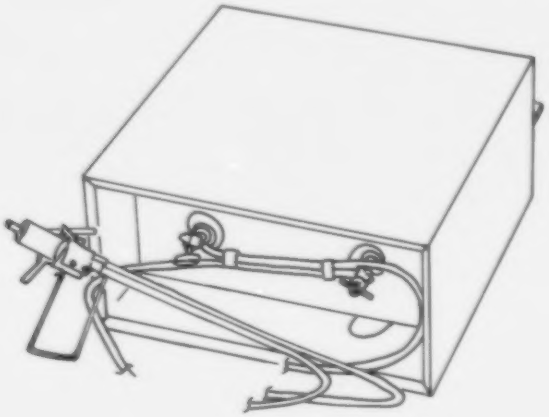
Huibregtse, K.R., Lafornara, J.P. and Kastmann, K.H., Envirex Inc.: "Inplace Detoxification of Hazardous Materials Spills in Soil", Proc. 1978 Nat. Conf. on Control of Hazardous Material Spills, pp. 362-370 (1978).

PRODUCT MSAR DIKE-PAK SYSTEM **No. 18**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – The system is designed to provide a lightweight, chemically-inert material to plug gratings and to dike or divert spills of hazardous chemicals on dry ground surfaces. It consists of two cylinders in a common carton with 1.8 m of applicator hose, an application gun and five spare tips.



OPERATING PRINCIPLE – As the gun trigger is activated, the blowing agent and urethane chemicals are released under pressure from the cylinders, mixed in the gun, producing a foam which is applied to the spill area.

PHYSICAL SPECIFICATIONS –

Total weight of system: 15.9 kg (35 lb) including 11.4 kg (25 lb) of urethane foam chemicals.
Portable self-contained unit.
Approximate size: 381 x 305 x 102 mm (15 x 12 x 4 in) high x wide x thick.
Universal Nozzles: Pencil-Like Spray or Fan-Like Spray

OPERATING SPECIFICATIONS –

Chemicals can be stored for up to 3 years without measurable deterioration (0°C to 38°C). Optimum performance temperature: 16 to 32°C.

Approximately 0.85 m^3 (30 ft^3) of foam can be applied to concrete, asphalt and similar surfaces.

Not suitable for blocking a flowing liquid stream, or on wet surfaces. Not recommended for use with materials such as chemical solvents, low molecular weight, polar or chlorinated hydrocarbons, due to softening and dissolving of the urethane structure. Can be used to control spills of chemical solvents by increasing dike thickness or by backup dikes.

STATUS OF DEVELOPMENT AND USAGE – Commercially available product utilized in the U.S.; no indication provided of wide usage in Canada (see also Other Data).

PERFORMANCE – Testing has been conducted by the manufacturer which showed the foam (once blown and rigid) to be unaffected by acrylonitrile, phenol, chlorine, ammonia and acetone-cyanohydrin. Methyl alcohol, however, soaked into the foam and destroyed the integrity of the material.

On bare ground surfaces, material holdup is limited since seepage occurs below the interface of the surface with the urethane.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

MSA Research Corporation
Evans City, PA 16033
U.S.A.
Telephone (412) 538-3510
Contact: Mr. C.H. Staub

Canadian Distributor:

MSA Canada
148 Norfinch Drive
Downsview, Ontario
Canada
M3N 1X8
Telephone (416) 667-9400
Contact: Mr. K.H. Brown,
Manager of Marketing

Cost-(effective October 1983 $ US)
Approximately $290.

OTHER DATA – System developed under sponsorship of U.S. EPA.
1 year warranty (manufacturer's claim).
Used once in Western Canada on a gasoline spill.
U.S. manufacturer indicated that Dike-Pak can be ordered through the Canadian Distributor but will be shipped from the U.S. Urethane may be toxic if not solidified.

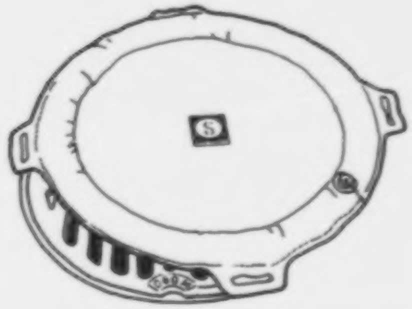
References: Manufacturer's Literature; personal communication - Mr. C.H. Staub, MSA Research Corp., (October 10, 1983). Mr. J.W. Mausteller, MSA Research Corp., October 10, 1983; Hiltz, R.H., M.D. Marshall and J.W. Friel, "The Physical Containment of Land Spill by a Foam Diking System", Proc. 1972 Nat. Conf. on Control of Hazardous Material Spills, pp. 85 to 91 (1972).

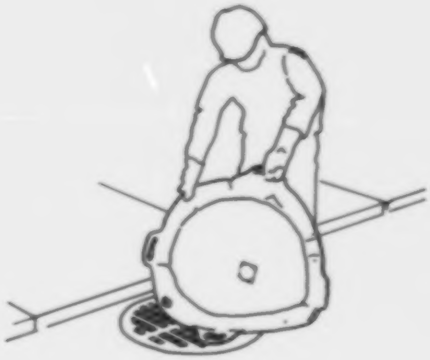
PRODUCT SANITRAP MANHOLE COVER **No. 19**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – A compact manhole cover designed to keep spilled oil and other similar liquids from contaminating sewers.





OPERATING PRINCIPLE – The tubular cavity around the perimeter of the cover provides a positive seal over a manhole grating when filled with a water/glycol solution.

PHYSICAL SPECIFICATIONS –

Dimensions: 91.4 cm (36 in) dia., including 7.6 cm (3 in) circumferential cavity for water/glycol solution.
Weight (filled): 15.9 kg (35 lb)
Material of Construction: 22 oz. Neoprene
Brass nozzle for filling and emptying.

OPERATING SPECIFICATIONS – Stored while filled with water/glycol solution for quick response.

STATUS OF DEVELOPMENT AND USAGE – Commercially available product. Documentation for application to spills of hazardous materials not obtained.

PERFORMANCE – Recommended for use by firemen, cleanup contractors, at airports, public works, refineries, and with truck tankers. No evaluation data received.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Sanivan Inc.
1705 3e Avenue
P.A.T. Montreal, Quebec
Canada
H1B 5M9
Telephone (514) 353-9170
Telex 05-829559
Contact: Mr. Pierre Richard

Cost: – approximately $125 (Cdn)
- Effective November, 1983
- Includes water/glycol solution

OTHER DATA – No other information received.

CONCEPT SOIL SURFACE SEALING No. 20

APPLICABILITY	Gas	Liquid Sol	Liquid Fl	Liquid Sk	Solid Sol	Solid Fl	Solid Sk
		*	*	*			

DESCRIPTION – A conceptual method to seal the soil surface to prevent the infiltration of a hazardous material spill to the substrata.

OPERATING PRINCIPLE – A sealant compatible with the spilled material is applied to sandy soils where it forms an impermeable or semi-impermeable film to prevent infiltration. Diking may also be used to contain the spill (see also Other Data).

PHYSICAL SPECIFICATIONS – Not applicable (concept only).

OPERATING SPECIFICATIONS – Not applicable (concept only).

STATUS OF DEVELOPMENT AND USAGE – Concept only that has included the laboratory testing of various chemical methods and that has also led to the identification of other approaches (see also Other Data).

PERFORMANCE – In laboratory-scale tests completed for the U.S. EPA, several potential sealants were screened; three polyurethane foam sealants were considered potentially applicable with these results:

	Candidate Sealants		
Test Materials	Bordon Chemical Polyco 2607	Callery Chemical Resin 115	Ashland Chemical EP 65-86/88
Sulphuric Acid	Passed	Passed	Questionable
Sodium Hydroxide	Passed	Passed	Failed
Phosphorus Trichloride	Passed	Passed	Passed
Phosphorus Oxychloride	Passed	Passed	Passed
Carbon Disulphide	Passed	Passed	Passed
Acetic Acid	-	Passed	Passed
Methylene Chloride	Questionable	Passed	Passed
Trichloroethylene	Questionable	Passed	Passed
Acetaldehyde	Questionable	Questionable	-
Benzaldehyde	-	Questionable	Passed
Acrolein	-	Passed	-
Isopropanol	Passed	Passed	Passed
Cresol	Passed	Passed	Passed
Ethyl Acrylate	-	Passed	Passed
Monoethanolamine	Passed	Passed	Passed
Pyridine	Passed	Passed	-
Acetone	Questionable	Questionable	Passed
Methyl Ethyl Ketone	Questionable	-	Passed
Naphtha	Questionable	Passed	Passed
Lacquer Solvent	Questionable	-	Passed
Gasoline	Passed	Passed	Passed
Kerosene	-	-	Passed
Xylene	Passed	Passed	-
Styrene	Passed	Passed	-
Vinyl Acetate	Passed	-	Passed

Further testing has also shown that the polyurethane foam sealants have application on sandy soils only. Small rocks and vegetation interfere with the sealant to the extent that the approach is not considered to be useful under such circumstances.

AVAILABILITY AND COMMERCIAL INFORMATION –

MSA has indicated that chemical methods, including polyurethane foam applied to sandy soils, are at the conceptual stage only. This U.S. EPA-sponsored work has largely been abandoned in favour of research reflecting the agency's preference for physical containment techniques (see also Other Data).

Contractor:	Sponsoring Agency:
MSA Research Corporation Evans City, PA 16033 U.S.A. Telephone (412) 538-3510 Contact: Mr. C.H. Staub	Oil and Hazardous Materials Spills Branch Municipal Environmental Research Laboratory-Ci U.S. EPA Woodbridge Avenue Edison, NJ 08837 U.S.A. Telephone (201) 321-6634 Contact: Dr. J.E. Brugger

OTHER DATA – Surface sealing studies have included a multi-prong approach taken by the EPA.

Callery Chemical Resin 115 is one component of the MSAR portable diking system Dike-Pak 150 (see entry this section).

Following evaluation of the polyurethane foam sealants, investigation has also been conducted of preformed, flexible, fabric-reinforced polyethylene panels used to cover and protect ground surface areas from spills. These are attached to each other using commercially available aluminum channel joining elements; the EPA-sponsored work has also been concerned with the application of large, flat plastic sheets having preformed bag-like containers along one edge to collect flowing, spilled liquids and so isolate the earth from the flow.

Test results to date have shown the simple mat format generally to be a more promising technique than chemical methods to prevent the intrusion of hazardous material spills into the ground. However, the main drawback of the panels is the time required to assemble them in order to achieve the desired sealing effect.

The most important offshoot of EPA's surface sealing research program has been the identification of a containment/collection system. Work has culminated, to this point, in the Capture and Containment Bag developed by MSA Research Corporation and being marketed by JRB Associates (see Entry No. 12, this section).

References: U.S. EPA Information Sheet, Contract/Grant Number: 63-03-2507 "Surface Sealing to Halt Groundwater Intrusion by Land", EPA Project Officer -Dr. J.E. Brugger, updated.

Personal communication, Dr. J.E. Brugger, U.S. EPA (February 14, 1984); Mr. C.H. Staub, MSA Research Corporation (February 8, 1984).

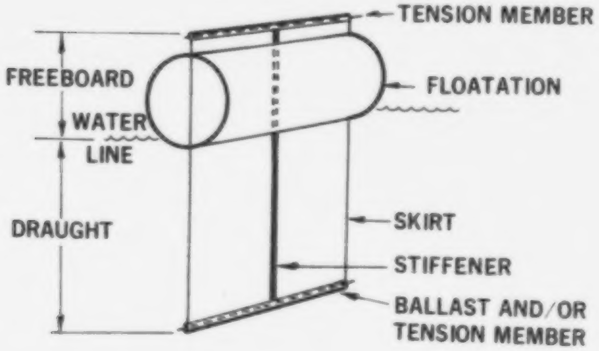
Lafornara, J.P., M.D. Marshall, M.J. McGoff, and J.S. Greer, MSA Research Corporation: "Soil Surface Sealing to Prevent Penetration of Hazardous Material Spills", Proc. 1978 Nat. Conf. of Control of Hazardous Materials Spills, pp. 296-302 (1978).

1.3 Containment on Water

PRODUCT SPILL CONTAINMENT BARRIERS - GENERAL LISTING **No. 21**

APPLICABILITY	Gas	Liquid			Solid		
		Sol	Fl	Sk	Sol	Fl	Sk
			*			*	

DESCRIPTION – A barrier comprised of a floating mechanical fence, sorbent material, pneumatic system or high water pressure spray serves to contain and concentrate floating materials in a water course for subsequent removal by physical recovery methods or in-situ burning.



OPERATING PRINCIPLE – Generally, there are four types of barriers:

(1) Mechanical Booms which rely on an upper or freeboard section incorporating polymeric foam and/or air chambers to provide both flotation and surface containment. A lower or draught section prevents subsurface losses and consists of a fabric or metal fence, or water chamber(s), ballasted by lead weights, chains or cables if necessary. Tension members - top, middle, and/or bottom - are often used to assume the load acting on the barrier and to assist in maintaining the barrier in a fully upright position.

(2) Sorbent Booms which consist of a porous outer shell containing an inner core of sorbent material. These devices are designed to halt the spread of contaminants while absorbing that portion which contacts them. They are less complex in design than mechanical booms and simply float at a level which exposes sorbent both above and below the water's surface.

(3) Pneumatic Barriers which utilize an air compressor to release air through perforations in piping submerged at the sea bed. Bubbles rise to the surface creating lateral currents which halt the spread of floating materials.

(4) High Pressure Water Booms which rely on a series of nozzles and a pumping system to produce water spray so directed as to herd and concentrate floating contaminants.

PHYSICAL SPECIFICATIONS – Data for the first three categories of barriers can generally be found in the Environment Canada draft publication "A Catalogue of Oil Spill Containment Barriers" released by the Environmental Emergencies Technology Division in November 1983. Of these three groupings of booms, mechanical barriers are by far the most widely commercially available. These, along with sorbent booms and pneumatic systems, are described in the catalogue organized according to an alphabetical index reproduced here. Names of companies that are capitalized appear in the catalogue as comprehensively presented main entries. More abbreviated entries are listed in upper and lower case letters. In both instances, product designations are given along with each company:

Specifications for the above booms are presented in the Environment Canada catalogue according to the following parameters:

Dimensions
- Overall Height (cm)
- Freeboard/Flotation (cm)
- Draught (cm)
- Section Length (m)
- Shipping Volume (m^3)

Weight
- Per Section (kg)
- Per Unit Length (kg/m)
- Upper Tension Member

Fabric
- Colour
- Type
- Tensile Strength (kg)
- Cold Crack Temperature (°C)
- Weight (g/m^2)

Flotation
- Shape, Type
- Dimensions

Buoyancy: Weight Ratio

Connector

Ballast/Lower Tension Member

Anchor Points
Vertical Stiffeners
Handholds

In the case of fireproof booms, refer also to:

(a) Buist, I.A., Pistruzak, W.M., Potter, S.G., Vanderkooy, N. and McAllister, I.R., "The Development and Testing of a Fireproof Boom", Proceedings of the Sixth Arctic Marine Oilspill Program Technical Seminar, Edmonton, Alberta (June 14-16, 1983).

(b) Meikle, K.M., "An Effective Low-Cost Fireproof Boom", Proceedings of the 1983 Oil Spill Conference, San Antonio, Texas (February 28 - March 3, 1983).

For preliminary information on the high water pressure system refer to:

Meikle, K.M., "The Use of High-Pressure Water for Spill Containment", Proceedings of the Sixth Arctic Marine Oilspill Program Technical Seminar, Edmonton, Alberta, (June 14-16, 1983).

Spill containment barriers are available in a wide variety of sizes and materials. Overall heights generally range from about 25 cm to 1 to 2 m (10 in to 3 to 6 ft) while common fabric types include PVC/nylon, PVC/polyester, neoprene/nylon, polyurethane or polyethylene/PVC, and polyamide/PVC. Fireproof booms have been fabricated in stainless steel, aluminum, asbestos panels and fibre-reinforced cement. Sorbent booms are, for the most part, comprised of hydrocarbon-base polymerics.

OPERATING SPECIFICATIONS – Because of time constraints, the use of physical containment procedures may not always be feasible to control sudden, accidental releases of floating hazardous materials, particularly at locations remote from countermeasures equipment depots or in flowing water bodies. Nonetheless, for some spills, mechanical barriers and, to a lesser extent, sorbent booms might have application. The latter are available in standard formats while the former are usually selected according to size so that an overall height to 50 cm (20 in) is generally suitable for nearshore or river use while booms 50 to 100 cm (20 to 40 in) are more effectively deployed in more exposed conditions. A general rule of thumb is to select a boom with a freeboard of at least 30% of the wave height to which it will be exposed; otherwise, most barriers will function adequately in calm water or will not be very effective in short, steep breaking waves.

Assuming the interception of floating materials is feasible, containment should be possible in currents ranging from about 0 to 0.8 m/s (0 to 1 1/2 knots). Angled deflection of material above 0.4 m/s (3/4 knot) should be attempted preferably using booms with a round flotation element and top and bottom tension members.

Insofar as the choice of fabric is concerned, it is likely that short-term use of a barrier on floating hazardous materials should be possible regardless of the fabric type. An exception would be, for example, exposure of a polyvinyl chloride/nylon barrier containing plasticizers to a high solvency chemical such as an organic alcohol in a ditch or other situation where continuous intimate contact over time occurred. Generally, neoprene, rubber-impregnated, modified rubber compounds, and polyurethane booms should be less susceptible to damage although for spills in watercourses the following factors should restrict the chance of gross failure of any boom:

- limited contact time;
- exposure of boom at waterline only;
- rising action of waves, water, and
- spreading, evaporation, dilution or other physical/chemical behavioural property of substance spilled.

STATUS OF DEVELOPMENT AND USAGE – Spill containment barriers, including mechanical, sorbent and pneumatic types, are commercially available and utilized world-wide particularly on oil spills. Documented use on hazardous materials is generally restricted to tank or laboratory testing for limited numbers of substances rather than on actual spill experience. Fireproof booms and high water pressure systems are generally at an earlier stage of development although several companies fabricate commercial barriers for in-situ burning.

PERFORMANCE – A summary of performance data for most commercially available booms is presented in the Environment Canada report "A Catalogue of Oil Spill Containment Barriers" (see also Physical Specifications). Although concerned only with oil, the catalogue likely reflects containment potential for most floating substances -according to location of application, design features, strength/durability, connection system and ease of use. Generally it can be stated that:

(1) Conventional mechanical booms can be selected that should provide containment or deflection potential for spills of hazardous materials if their timely deployment is practical.

(2) Sorbent booms similarly should have application to spills, albeit on a more restricted basis (i.e., smaller spill volumes, compatible substances and calmer water).

(3) Pneumatic barriers are not likely to offer a viable spill control alternative unless applied to a long-term, shallow water, low current situation (less than 0.26 m/s (1/2 knot)) release of floating chemical.

(4) High water pressure systems are in the research and development stage; their weight and power requirements may preclude their use on smaller, discrete discharges of hazardous materials spills.

(5) Fireproof booms are being developed or, in several cases, are commercially sold. While the concept of in-situ one-step removal of a floating hazardous material is appealing, deployment considerations including timing, ease of handling and safety should first be examined.

AVAILABILITY AND COMMERCIAL INFORMATION – Consult Solsberg, L.B., "A Catalogue of Oil Spill Containment Barriers", Environment Canada, Ottawa, Ontario, November 1983.

OTHER DATA – Refer also to Robinson, J.S., "Hazardous Chemical Spill Cleanup", Noyes Data Corporation, Park Ridge, NJ, U.S.A., 1979.

Commercially - Available Booms

ACME PRODUCTS CO.
  OK Corral Boom - Standard Model
  OK Corral Boom - Heavy Duty Model

Ajit Shah, Inc.
  Expandi Boom

ALBANY INTERNATIONAL
  Oilfence 16, 24, and 36

AMERICAN BOOM & BARRIER CORP.
  Mini Booms (Skimming, Sweeper, Banter, Contain-it)
  Flat/Fence Booms (CG, CG-1, 3 & 4)
  Mark I, II Booms
  Mark III, IV Series (A, B & C models)

BIGGS WALL FABRICATORS LTD.
  Reel Boom (Biggs-Hoyle Reel Boom)

Blue Water Marine Supply, Inc.

Bridgestone Tire Co., Ltd.
  Floating - Submerging Oil Fence

British Petroleum Company Limited
  Weir Boom System

Cascade Industries Incorporated
  Permanent Harbor Boom

CENTRIFUGAL SYSTEMS, INC.
  CSI Boom Model 1, 2 Series
  CSI Boom Model 3 Series

- AMERICAN MARINE, INC.
  - Minimax & Maximax
  - Simplex, Optimax, Supermax
  - Permafence 18, 24, 36, 48

- Atlas Copco Canada Inc.
  - Pneumatic Barrier

- Bennett Environmental Consultants Ltd.
  - Firefence

- Bennex A/S Marine Products and Services
  - Nofi Boom

- BF Goodrich Engineered Systems Company
  - Seaboom

- COVALCA PLASTICI S.p.A.
  - 65/625 & 65/640
  - Offshore 85/1025

- CROWLEY ENVIRONMENTAL SERVICES, CORP.
  - Petro Barrier 24" and 36"

- Darcy Products Limited
  - Drizit

- DIAB-BARRACUDA AB
  - Barracuda Oil Boom

- ENVIRONETICS, INC.
  - Boa Boom I
  - Boa Boom II and III

- EXPANDI SYSTEMS AB
  - Expandi-Boom Models 2000 & 3000
  - Expandi-Boom Types 4300 & 6300

- Fluid Solids Inc.

- GAMLEN EUROPE S.A.
  - Gamspill & Offshore (1500 models)
  - Hi Sea Guard
  - Fire Guard (Standard and Heavy Duty models)

- GOODYEAR AEROSPACE CORPORATION
  - Sea Sentry 9-18, 12-24 and 14-24

- Grefco Inc.
  - Grefco Sorbent Boom

- Harmstorf Limited
  - Pneumatic Oilbarrier

- HURUM ENGINEERING LTD.
  - Hurum 18" Disposable Boom
  - Flexy II

- Hydrotechnik Lubeck
  - Floating Booms

- Industrial Plastics Canada Ltd.
- Slickbar Mk 7, 10 & 12

- Coastal Services
  - Coastal Oil Boom

- Colloid Chemical Company
  - Spilldam - 360 Oil Containment Boom

- CONPLAN INTERNATIONAL AB
  - Safe Barrier

- CONTAINMENT SYSTEMS, CORPORATION
  - 4 x 6, Performance Harbor Booms
  - River, Fence Booms

- CONWED CORPORATION
  - Disposable Boom

- Jackson (P.D.) Ltd.
  - Pollution Net

- Jaton Environ Inc.

- Johns-Manville
  - Spillguard Boom

- KEPNER PLASTIC FABRICATORS, INC.
  - Standard Seacurtain, Sea Tender
  - Seacurtain - Compactible, Supercompactible, Reel Pak

- Kleber
  - Balear and Acorn Booms

- Landrigan Corp.

- Lans-Marin AB
  - Sors Screen

- Logan Engineering & Contracting Company
  - Underwater Canopy (Aqua Dome)

- Lunastran Inc.

- MANNESMANN ITALIANA SpA
  - R2
  - R11
  - PNA

- Mannesmann Italiana SpA
  - Merkalon, Stainless Steel booms

- Marsan Corp.

- MEGATOR CORPORATION
  - Megator Mini-Boom

- Metropolitan Petroleum Petro Chemicals Co., Inc.
  - MP Boom

- McDonald R. David (MRD), Incorporated
  - MRD Semi-Disposable Boom

- Morris International Trading Ltd.
  - Semi-disposable Boom (MI-20B)

INTERTRADE INDUSTRIES LTD.
Oil Spill Guardian IW13, IH24 & OH36
OS44 and P36

Murphy Pacific Marine Salvage Co.

Nautylatex Canada Ltd.
Balear and Acorn Booms

NOFI A/S
Nofi Oil Containment Boom System

NORDAN INTERNATIONAL A/S
Nordan Booms - Harbour, Sea & Ocean

NORGAS AS
Skuteng Oil Boom

Norske Telektron A/S
Purse Seine Oil Boom

NOUVELLES APPLICATIONS
TECHNOLOGIQUES
NAT, Bapinox Booms

Ocean Systems Inc.
Harbor Oil Containment Barrier

OFFSHORE DEVICES, INC.
Harbor Barrier - Scoop
Offshore Barrier

Oil Pollution Environmental Control Ltd.
Expandi Boom

OIL RECOVERY INTERNATIONAL
Harbourgard HG 15, 22, 30 & 40

Pace
PACE Oil Boom

Pacific Pollution Control
Aqua Fence

Pains-Wessex Canada Ltd.
Floating, Submerging Oil Fence

PARKER SYSTEMS, INC.
PSI Boom - Bantam, Basin, Regular &
Heavy Duty
Spill Master Permanent Boom 24, 36-URE

Permalite Europe

Pollution Booms, Inc.
Oil Slick Barriers

Steltner Development & Manufacturing
Company Ltd.
PACE Oil Boom

Submarine Engineering Associates, Inc.,
Sea Boom

MSE Engineering Systems Ltd.
Intertrade, Megator Booms

Quincy Adams Marine Basin Inc.

Response Systems Incorporated
Expandi Boom

Reynolds Aluminum International
Services, Inc.

RHIN-RHONE
IRHR Type 22 and 13

ROLBA
Rolip Boom

ROULANDS FABRIKER A/S
Ro-Boom Bay & Class OSA
Ro-Boom River Model

SAMSEL SERVICES COMPANY
Standard Harbor Boom

SANIVAN INC.
SK Boom-SK 18/6, 20/7, 24/8 & 36/9
Semi-Disposable SK 14/4 and SK 18/6
Permanent Boom

SCANDINAVIAN OIL SERVICE
SOS Permanent Booms Type 200 & 400

SEAWARD INTERNATIONAL, INC.
Sea Fence Inner & Outer Harbor Boom

SJUNTORP AB
SORS Screen Models 530 & 1030 & 2030

Skimmex Ltd.
Oil Retaining boom - SK, ZIG-ZAG and
Shoreline Barriers

Skuteng A/S
SOOPRES System

SLICKBAR, INCORPORATED
Mk7, 10 & 12 - Standard Models

Smith-Anderson Co. Ltd.

Sorbent Products Co., Inc.
SPC Sorbent Boom

Spearin, Preston & Burrows, Inc.
Harmstorf Pneumatic Oilbarrier

Trygve Thune A/S
T-T Boom

UNIROYAL INC.
18" Boom Mini-Boom & Hi-Performance
36" Boom Standard, Outer Harbour
& Two-Ply

- Sunshine Chemical Corp.
- Surface Separators Systems, Inc.
  - Uniroyal Booms
- Svensk Oljetral AB
  - Swed Trawl
- SWED SORB INTERNATIONAL
  - Oil Eater
- Swed Sorb International
  - Swed Trawl
- Tampella AB
  - SUP Booms
- The Tarp Shop
  - SUP Booms
- 3 M
  - Sorbent Boom
- Trelleborg AB
  - Troilboom
- TROIL BOOM SYSTEMS AB
  - Troilboom Models 750 & 1100
  - GP Oil Boom 920
  - Troilboom 1500 Compacy & Heavy Duty
- United McGill Corp.
- VERSATECH PRODUCTS, INCORPORATED
  - General Purpose Boom (Bennett Boom)
  - Inshore Boom Models 18 and 36 (Bennett Boom)
  - Nav-Pak (Bennett Boom)
  - River Boom (Bennett Boom)
  - Zoom Boom (Bennett Boom)
  - El Cheapo Semi-Disposable Boom
  - Permanent Harbour Boom Models 18 and 30 (Bennett Boom)
- VIKOMA
  - Beach Guardian
  - Coastal, SeaPack & Boom Deck Reel
- Welsh Oil-Tech Ltd.
- White, H.S. Co. Inc.
- Whittaker Corp.
  - Expandi Boom
- WILLIAM WARNE LIMITED
  - Warne Anti-Pollution Boom T8 and T16
  - Warne Anti-Pollution Boom E16, E8 and S

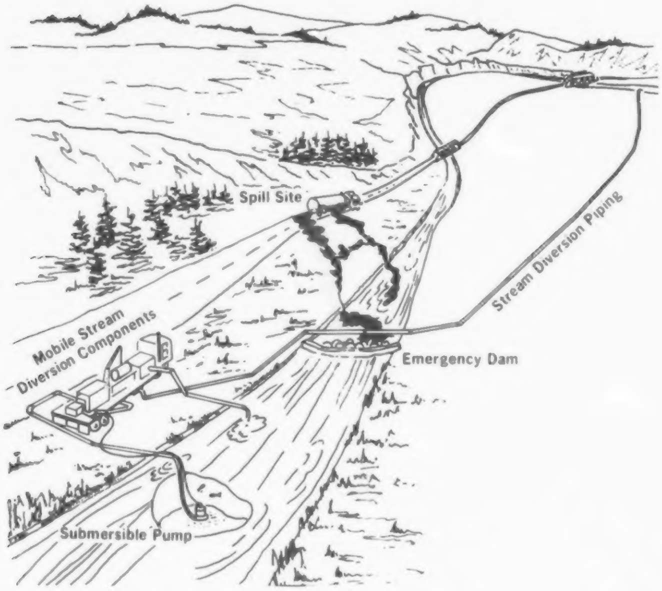
1.4 Containment in Water

PROTOTYPE MOBILE STREAM DIVERSION SYSTEM **No. 22**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
			*			*

DESCRIPTION – Prototype. A system to divert streamflow past a point where a hazardous material which sinks or forms an insoluble precipitate on contact with water has been spilled. The system consists essentially of pumps and piping.



OPERATING PRINCIPLE – A dam is constructed upstream of the spill area. A pump is located in the stream and pumps the streamflow through pipes to a point downstream of the spill area, thereby isolating it for decontamination.

PHYSICAL SPECIFICATIONS –

Item	MFR/Model	Specifications
Tractor 2 each	Mack Maxidine RL 795L5T	325 hp diesel engine; 2 rear axles, tandem interlock
Trailer 2 each	Fruehauf PF-F2-40	12.2 m trailer w/Budd wheels; 27 000 kg capacity
Submersible Pump 4 each	Peabody Barnes 6SEH4004	29.8 kW, 3-D, 460 V, 0.8 PF, 152 mm discharge 21 m No. 2 AWG 4-wire power cable with 600 V 100 amp "Powertite" connector

Generator 2 each	Electro Motion 125 T 6	100 kW continuous duty (125 kW standby) 265/460/575 V 3-D, water-cooled Allis-Chalmers Model 11000 diesel engine, Kurz a revolving field 100 kW generator
Booster Pump 4 each	Reiner, GP-110-3 (government-furnished equipment)	Two-stage, 152 mm, 0.09 m^3/s, 8 gasoline driven centrifugal pump 370 cm head
Crane 2 each	International Crane Model 309-4	2 700 mg capacity
Cable Reels 4 each	Hannay C 3034-24-26	100 m storage capacity for No. 4 AWG 4-wire cable
Cable electric	Cereske Cable No. 4 AWG 600 V 50 cable	4 each, No. 4 AWG 4-wire, 86 m
Floodlight 4 each	Sylvania 1500 T 3Q/CL 277 V	
Tool Box 1 each	12-gauge steel box with SSI-selected tool complement	50 piece selection of maintenance and repair tools, and controllers
Winch 1 each	Ramsey DC 12-8	2 700 kg, 12 V DC portable electric winch SSI dolly mounted
Water Meter 2 each	McCrometer, Model MC 0500 305 mm meter	0.01 to 0.2 m^3/s
Rack/Dolly 2 each	Scientific Service, Inc.	2.4 x 5.4 x 0.5 to 0.7 m (wide x long x deep)

Item	MFR/Model	Specifications
Rack/Dolly 2 each	Scientific Service, Inc.	2.4 x 5.4 x 0.6 m (wide x long x deep)
Control Center 2 each	Scientific Service, Inc.	
Pipe & Hose (Approx. 1 km)	ASC Mainline/Circle Lock (C/L) Agricultural Irrigation Aluminum Pipe with steel fittings	203 mm I.D. tubing, 9.1 m length 1.63 mm wall 68 pieces (32.1 mg/length); 152 mm I.D. tubing, 9.1 m length; 1.47 mm wall; 24 pieces (21.7 kg length) 203 mm I.D. tubing, selected lengths; 1.63 mm wall; 16 pieces (various weights, less than 15 kg/length)
	ASC Mainline/Circle Lock Connectors, B.F. Goodrich Nylair 44 hose and hose patches	33 sections flexible hose couplings, 50 m total
Pipe Fittings	ASC Mainline/Circle Lock Aluminum and Steel	

OPERATING SPECIFICATIONS –

Capacity on Level Terrain
0.35 m^3/s for a distance of 0.3 km
0.09 m^3/s for a distance of 11 km

STATUS OF DEVELOPMENT AND USAGE – Prototype unit has been utilized in the U.S. on one incident only. This indication of a low level of need for the approach has resulted in its being removed from service by the EPA.

PERFORMANCE – The system has been used during an emergency response to a spill episode that contaminated a public water supply. The use of the stream diversion system insured uninterrupted service to the affected communities.

AVAILABILITY AND COMMERCIAL INFORMATION –

Contractor:

Scientific Service, Inc.
1536 Maple Street
Redwood City, CA 94063
U.S.A.
Contact: Mr. C. Wilton

Sponsoring Agency:

Municipal Environmental Research Laboratory
Oil and Hazardous Materials Spills Branch
U.S. EPA
Edison, NJ 08817
U.S.A.
Telephone (201) 321-6632
Contact: Mr. F.J. Freestone

OTHER DATA – Refer also to the following report for system design, component selection, trailer layout, site preparation and system operation: Zaccor, J.V., A Mobile Stream Diversion System for Hazardous Materials Spills Isolation, EPA-600/2-81-219, Cincinnati, Ohio (September 1981).

Report available only through:

U.S. National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
U.S.A.

References: Freestone, F.J., and Zaccor, J., Scientific Service, Inc.: "Design, Fabrication and Demonstration of a Mobile Stream Diversion System for Hazardous Material Spill Containment", Proc. 1978 Nat. Conf. Control of Hazardous Materials Spills, pp. 371-377 (1978).

U.S. EPA, Environmental Emergency Response Unit Capability, Office of Research and Development, p. 14 (May 1980).

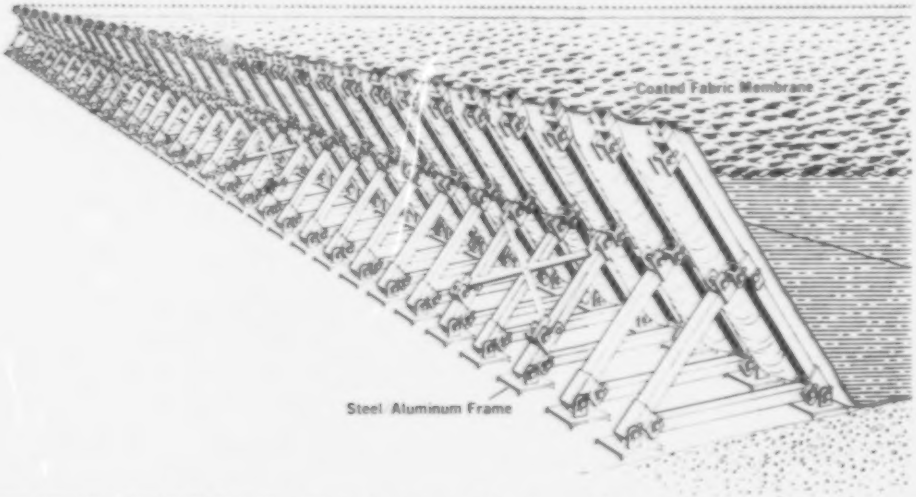
personal communication, Mr. F.J. Freestone, U.S. EPA (February 15, 1984).

PRODUCT PORTADAM OIL BARRIER **No. 23**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*	*	*	*

DESCRIPTION — A patented coffer dam capable of retaining contaminated water in rivers and streams until removal of hazardous materials is complete. It consists of a braced metal structure which supports a reinforced fabric membrane.



OPERATING PRINCIPLE — The Portadam system is erected by setting the frame structure at an angle that directs hydrostatic pressure down onto the ground. The frame is braced against lateral forces and correctly spaced to fit the membrane. The membrane is pleated and attached to the frame by high strength loops, extended and clamped on the ground by water pressure.

PHYSICAL SPECIFICATIONS —

Frame — Length: 1.5 m (basic) to 2.4 m ft (standard) (5 to 8 ft).
Constructed of high quality steel or aluminum tubular sections and galvanized.

Braces — Chains or steel plates.

Membrane — Constructed with a series of pleats, tailored from a high strength, durable, coated fabric.

Standard Size: 9.1 m (30 ft) or 18.3 m (60 ft).

Can be made to other specifications.

OPERATING SPECIFICATIONS — Can be used in water depths up to 3.1 m (10 ft).

Basic 1.5 m (5 ft) frame can be extended to 2.4 m (8 ft) by means of telescopic extension.

Spacing between frames is 380 mm (15 in) centre to centre (by means of U rods or spacer chains).

Depending on soil conditions, bracing chains or X frames are placed at 7.6 m (25 ft) centres.

Special pleating system in the membrane ensures correct distribution over the support structure.

Coated fabrics are available to resist oil, acids, etc. and to perform at low temperatures. Can be modified for hazardous material spill containment.

STATUS OF DEVELOPMENT AND USAGE – Developed to commercial product stage. Use not documented for hazardous material spills.

PERFORMANCE – Evaluation data are not available.

AVAILABILITY AND COMMERCIAL INFORMATION – Portadam has been fabricated in Canada by Conenco International Limited of Markham, Ontario. This company no longer operates in Canada.

OTHER DATA – Development of Portadam Oil Barrier System under Environment Canada sponsorship, is described in the Final Report, Development of Portadam Oil Barrier for Rivers and Streams, 11 April 1979, Conenco International Limited.

Emergency Dams – It is suggested that for emergency purposes, the dams should be supplied on pallets which may be loaded by fork-lift truck on trailers. Each pallet would typically contain sufficient frames and membranes for a 50 m (164 ft) length of dam, plus a kit of other equipment which might be useful at a totally unprepared site such as shovels, ropes, knife, sandbags, cartridge-operated fastening gun (for fixing dam ends of fabric to concrete), sledge hammers, spare webbing ties, chain-edged sealing sheet for manoeuvring over leaks or holes in flood walls and membrane repair kit.

Reference: Manufacturer's Literature; personal communication, R. Parent, (September 19, 1983).

For further information contact:

Mr. Merv Fingas
Environmental Emergencies Technology Division
River Road Environmental Technology Centre
Ottawa, Ontario
K1A 1C8

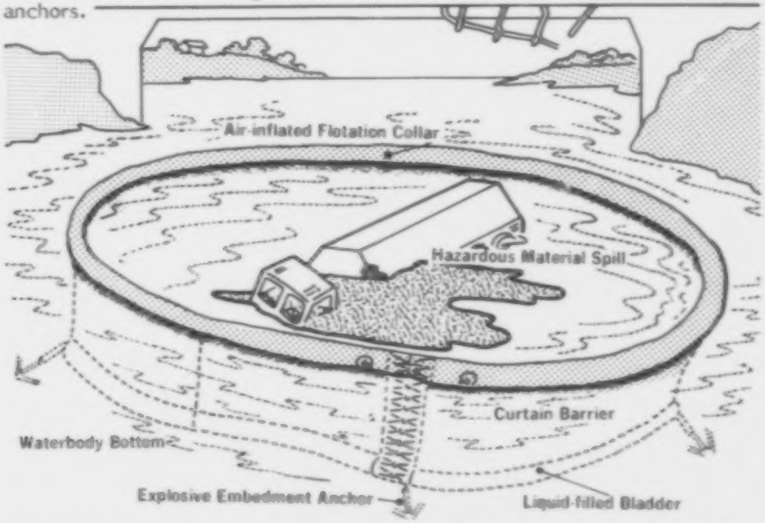
Telephone (613) 998-9622

PROTOTYPE SEA CURTAIN BARRIER **No. 24**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*	*	*	*

DESCRIPTION – A floating barrier which extends to the bed of the waterway. Consists of a boom and anchors.



OPERATING PRINCIPLE – The barrier is deployed to encircle the spill location. Explosive anchors are fired into the bed of the lake or stream and attached to the boom. The weighted bottom of the boom forms a seal along the bed of the waterway.

PHYSICAL SPECIFICATIONS –

Materials: Boom - Herculite 20 (nylon filament reinforced plasticized PVC fabric)
Cordage, Hardware and Fastening Materials - Nylon or PVC

Anchors
- Five explosive embedment anchors made by EDO Western Corp.
- Weight: 27.2 kg (60 lb) each
- Vertical pullout strength for sand and mud 4535.1 kg (9998 lb)

Dimensions: 61.0 m (200 ft) long x 9.1 m (30 ft) high
Interconnection of boom lengths is with laces and a velcro strip.
Flotation: Air
Ballast: Water or heavy solution

OPERATING SPECIFICATIONS – For waterways depth from 3.0 to 7.6 m (10 to 25 ft); Current up to 1.0 m/s; Chemical resistance of the barrier materials is as follows.

STATUS OF DEVELOPMENT AND USAGE – Developed to prototype stage only by the U.S. EPA. Further technical refinement is possible, pending funding. Current plans by the U.S. EPA do not include development of the Sea Curtain to a commercial product (see also Performance).

PERFORMANCE – Tests performed for the EPA yielded the following results:

Bear Lake, Utah - Anchor penetration and attachment tested with satisfactory results; water depth about 7.6 m (25 ft) over a coarse silt; anchor penetration was from 4.0 to 6.4 m (13 to 21 ft).

Sugar Grove, WV - total system deployment tested for use in a quiet water condition; total deployment time 6 hours; the barrier effectively contained a test spill of Rhodamine-B fluorescent dye.

Chemical	Herculite Fabric with Plasticized PVC	Nylon Line
Phenol	A-B	A
Methyl Alcohol	A	A
Insecticides, Rodenticides	A	A
Acrylonitrile	A	
Chlorosulphuric Acid	A	A-B
Benzene	B	A
Ammonia	A	A
Misc. Cyclic Insecticides	A	A
Phosphorone Pentasulphide		
Styrene	B	
Acetone Cyanohydrin	A	
Chlorine	A	
Nonyl Phenol		A
DDT	A	A
Isoprene	A-B	
Xylenes		A

A = Satisfactory for Use
B = Satisfactory in Certain Circumstances
C = Unsatisfactory
* where a rating is not given, the chemical resistance is unknown

(NOTE: These ratings are for chemicals in concentrated form. Resistance will be better for diluted forms.)

Lakeworth, Florida 1976 - An advanced, modified prototype was evaluated which had increased strength and improved chemical and abrasion resistance. The tests revealed difficulties associated with the barrier's deployment, including achievement of the seal along the bottom edge (the bottom portion of the device is a flexible water-filled chamber), and removal of the system after use.

AVAILABILITY AND COMMERCIAL INFORMATION –

Original Contractor
(see also Other Data):
Samson Ocean Systems, Inc.
1386 Park Center Road
Hendon, VA 22070 U.S.A.
Contact: Mr. T.N. Blockwick

Sponsoring Agency:
Oil and Hazardous Materials Spills Branch
Municipal Environmental Research Laboratory-Ci
U.S. EPA, Woodridge Avenue
Edison, NJ 08817 U.S.A.
Telephone (201) 321-6635
Contact: Mr. I. Wilder

OTHER DATA – Consult also: Blockwick, T.N., Evaluation of a Containment Barrier for Hazardous Materials Spills in Watercourses, EPA-600/2-83-112, U.S. EPA, Cincinnati, Ohio (December, 1983).

Report available only through:

U.S. National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161 U.S.A.

Refer also to:

Samson Ocean Systems, Inc.
99 High Street
Boston, MA 02110 U.S.A.
Telephone (617) 426-6550
Contact: Mr. H.A. McKenna

References: Brown, L.S., Ocean Systems Inc.: "A Physical Barrier System for control of Hazardous Material Spills in Waterways", Proc. 1972 Nat. Conf. on Control of Hazardous Materials Spills, pp. 93-102 (1972).

Brugger, J.E. and Wilder, I., A Review of the U.S. EPA's Research Program on the Prevention and Control of Hazardous Material Spills, Journal of Hazardous Materials, Volume 1 (1975/76) 3-19, Amsterdam, The Netherlands.

personal communication, Mr. F.J. Freestone, U.S. EPA (February 15, 1984).

1.5 Vapour Control

CONCEPT MECHANICAL COVERS - GENERAL LISTING **No. 25**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
*	*	*	*			

Applicable to vapour rising from a pool of spilled liquid.

DESCRIPTION – Concept. A release of hazardous chemical is covered by a sheet of continuous material, spray of a continuous cover, or the placement of buoyant particles or shapes.

OPERATING PRINCIPLE – The cover placed over the spilled chemical contains the vapour cloud so that it can be subsequently collected.

PHYSICAL SPECIFICATIONS –

1) Floating Covers Hypalon membrane 0.8 to 1.1 mm thick (fitted with polyurethane floats) in 7.6 m widths covering up to 9750 m^2.

Polyethylene film 4 to 10 mils, up to 12 x 30 m, weighing 34 -91 kg/373 m^2 roll.

Butyl, EPDM, neoprene and other synthetic rubbers 0.8 to 3.3 mm thick, in 12 x 30 m rolls, weighing 227 to 1000 kg/372 m^2 roll.

Vinyl, other common plastics and polyurethane are alternative cover materials.

2) Sprayed Cover Urethane.

3) Array of Particles Hollow spheres, closed-cell foams in glass, polypropylene and polyurethane.

Geometrical ordering of dodecahedron particles to produce a close-packed array; 1 000 particles/0.38 m^2 coverage.

OPERATING SPECIFICATIONS – Detailed operating criteria were not obtained. Deployment of all concepts would take place from the upwind side of the spill, likely at low (8 km/h) wind speeds. In the case of floating covers, suitable flotation or mechanical support would have to be provided; deployment of the cover in combination with a floating containment barrier might constitute one approach. Particle arrays would also be applied in a floating mode whereas the primary use of a sprayed cover would be on land.

STATUS OF DEVELOPMENT AND USAGE – Use of all concepts has not been documented for spills of hazardous materials. Floating covers have been used to contain vapours over lagoons. Particle arrays have been applied to open storage tanks, ponds and reactor vessels to reduce evaporative losses. Sprayed covers have been investigated as a means of vapour control but foams seem to offer more potential in this regard.

PERFORMANCE – Evaluation data were not obtained.

Use of mechanical covers "requires acquisition in advance of the spill and storage until needed, and in all but small spills, deployment may be problematical."

The research and development of sprayed covers has shown less promise than the approach of containing and collecting an accidental release using a flexible bag; however, spraying sandy soil with a chemical cover may be effective in some situations.

AVAILABILITY AND COMMERCIAL INFORMATION –

Floating Covers:

Globe Linings, Inc.
P.O. Box 7396
Long Beach, CA 90807
U.S.A.

Gulf Seal Corp.
P.O. Box 508
South Houston, TX 77587
U.S.A.

Carlisle Tire and Rubber
P.O. Box 99
Carlisle, PA 17013
U.S.A.
Telephone: (717) 249-1000

Packed Array:

Plastic Systems, Inc.
Santa Anna, CA
U.S.A.

Sprayed Covers:

Oil and Hazardous Materials Spills Branch
Municipal Environmental Research Laboratory-Ci
U.S. EPA
Woodbridge Avenue
Edison, NJ 08837
Telephone (201) 321-6634
Contact: Dr. J.E. Brugger

OTHER DATA –

References:

Bennett, G.F., Feates, F.S. and Wilder, I., Hazardous Materials Spills Handbook, McGraw-Hill Book Company (1982).

Robinson, J.S., Hazardous Chemical Spill Cleanup, Noyes Data Corporation, Park Ridge, NJ, U.S.A. (1979.)

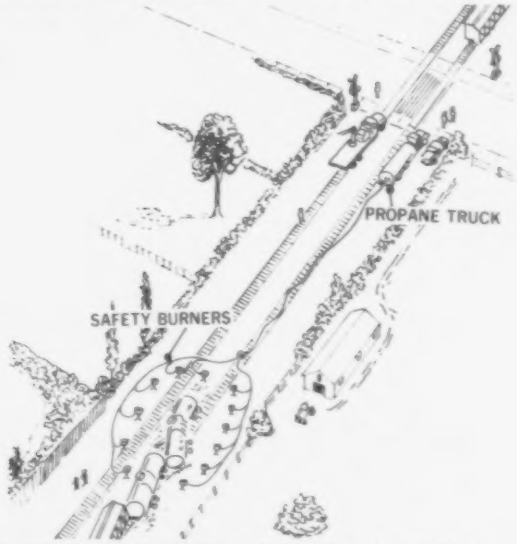
personal communication, Dr. J.E. Brugger, U.S. EPA (February 14, 1984).

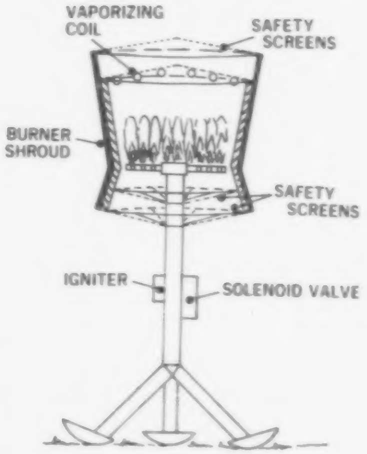
CONCEPT MOBILE GAS DISPERSION SYSTEM No. 26

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
*						

DESCRIPTION – Concept. A mobile system designed to disperse accidental releases of an airborne material.





OPERATING PRINCIPLE – Safety burners utilizing propane encircle a damaged railway car so that the heat they generate entrains, elevates and disperses the released hazardous gas in a rising thermal plume.

PHYSICAL SPECIFICATIONS – System components include:

A propane tank truck to provide fuel for Safety Burners; capacity: 26 500 to 30 300 L (7000 to 8000 U.S. gal).

12 Safety Burners rated at 4.4 MW deployed around the cars at a burner-to-burner spacing of 7.6 m (25 ft) which allows access to the damaged cars.

A standard truck designed for delivering concrete block and bricks and capable of good off-road performance. This is to transport the burners, pipe, cable, power/control unit, etc.; 6 x 2.6 m (20 x 8.5 ft) flat bed, e.g., GMS Brigadeer 9500 series.

A hydraulic loader/unloader, e.g., Wajax Industries unit, mounted on the truck and capable of a maximum reach of 8.5 m (28 ft) and a lifting capacity of 800 kg (1764 lb).

Power/control unit consisting of a 3kW, 120 V gasoline generator set; solenoid-operated propane valves; weatherproof control panel and electric cables; 1 m (3 ft) cube weighing 135 kg (300 lb).

Sensors for chlorine and flammable vapour plus a gas analyzer capable of identifying a variety of hazardous gases. A simple anemometer and wind direction instrument, on a stand, "will also be provided" to give immediate, local wind data. For the reference design, the following units were proposed:

- two Gastech Model 1177, solid state, combustible gas sensors;
- two Interscan Model 1340 portable chlorine gas detectors;
- one Century System Model OVA-128 portable multi-gas analyzer;
- one portable wind speed and direction sensor. This will be a simple anemometer and vane instrument, plus a compass, mounted on an aluminum stand.

OPERATING SPECIFICATIONS –

Operation Time:	3 1/2 to 4 hours based on one propane truck
Propane Consumption:	10.3 L/min at 700 kPa
Burner Airflow:	9.5 m^3/s (330 ft^3/s) @ maximum temperature of 370°C (700°F) based on 4.4 MW of heat produced
Wind Speed:	8 km/h or less results in vertical plume rise within ring formed by burners
Spacing:	burners at 7.6 m (25 ft) intervals connected as two branches of six burners each with control unit 30 m (98 ft) outside ring of burners and propane truck 150 m (492 ft) further back

STATUS OF DEVELOPMENT AND USAGE – Concept proposed for spill control; fixed array in service at two Canadian chemical processing plants.

PERFORMANCE – No previous usage on spills of hazardous materials spills. Testing and modification programs have been conducted to document and improve burner performance. Safety of this approach at spills requires investigation.

AVAILABILITY AND COMMERCIAL INFORMATION –

Proponent:

DSMA Atcon Ltd.
4195 Dundas Street West
Toronto, Ontario
Canada
M8X 1Y4

Sponsoring Agency:

Transport Canada Research and Development Centre
1000 Sherbrooke St. W.
P.O. Box 549
Montreal, Quebec
H3A 2R3

Estimated cost (March 1980) based on 13 burners and above Physical Specifications:

Item	Cost ($ Cdn)
Propane Tank Truck	90 000
Flat Bed Truck Plus Hydraulic Arm	63 000
Burners	75 000
Sensors	17 000
Power/Control Unit	8 500
Propane Lines and Electric Cables	33 000
Miscellaneous	9 500
System Assembly	30 000
General and Administrative Cost	15 000
TOTAL	$341 000

OTHER DATA – Information on this sytem is contained in the report:

Mooney, B.L., A. Robertson, A.G. Scott, and B.C. Stonehill, Definition and Evaluation of a Mobile Gas Dispersion System, DSMA 1134/1093, Toronto, Ontario (March, 1980).

PRODUCT MSA PORTABLE FOAMAKER **No. 27**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
*	*	*	*			

DESCRIPTION – A mobile system designed to produce high expansion foam to suppress the release of volatile vapours from hazardous material spills. It consists of a foam generator (eductor) and a can-like container with a mesh-screen at the outlet. Various size models are available.

OPERATING PRINCIPLE – High expansion foam, produced by mixing water and foam concentrate, is discharged to the spill area by means of water pressure, compressed CO_2, and/or electric fan action.

PHYSICAL SPECIFICATIONS –

MSA Portafoamaker 150

Size:	Handheld portable unit operated by one person.
Capacity:	9.5 L (2.5 U.S. gal) water plus 590 cm^3 (20 oz) foam concentrate.
Power Source:	CO_2 bottle and pressure regulator which maintains 830 kPa (120 psi) over spilled liquid.
Components:	Tank, CO_2 bottle, bottle actuator, rubber hose, squeeze-type valve, 7.62 cm (3 in) MSA foam generator, pressure regulator.

Model 3000 Foamaker Generator

	Water-Powered	Electric-Powered
Size:	483 mm Diameter 1 225 mm long with fireproof metal screen	483 mm diameter 945 mm long with fireproof metal screen
Weight:	50 kg	52 kg
Power:	Water-driven turbine single phase 60 cycle	Electric motor, 1/2 hp, 110/220 VAC
Screen:	Fireproof metal	Fireproof metal

Mine Model Foamaker Generator

Rubber tire or skid mounted unit.
Compressed-air motor.
Power requirements: 90 VDC, 128 VDC, 275 VDC, (Model A and Model B) 550 VDC, 220/440 VAC, 550 VAC.
Weight: Model A and Model B 363 kg (800 lb).
Diameter of foam outlet: Model A: 914 mm (36 in)
Model B: 1219 mm (48 in)
1/2 hp motor, foam agent pump drive.
Fan assembly: 3 hp motor.
3 spray nozzles.
Pressure regulator.

Model 6000 Foamaker Generator

	Water-Powered	Electric-Powered
Size:	914 mm (36 in) diameter 1168 mm (46 in) long	914 mm (36 in) diameter 1524 mm (60 in) long with fireproof metal screen
Weight:	101 kg (223 lb)	102 kg (225 lb)
Power:	Water-driven turbine	Electric motor, 1 hp, 110/220 VAC, single phase, 60 cycles
Screen:	Fireproof metal	Fireproof metal
Hose Fittings:	-	38 mm (1 1/2 in) National Standard Thread

OPERATING SPECIFICATIONS –

MSA Portafoamaker 150

Water Requirements: fixed 9.5 L (2.5 U.S. gal) capacity
Foam Expansion Ratio: 500:1
Foam Output: 4.25 m^3 (150 ft^3) per two minute discharge period
Throw Distance: 1.22 to 2.44 m (4 to 8 ft) at a height of 1.22 m (4 ft)

Model 3000 Foamaker Generator

	Water-Powered	Electric-Powered
Water Requirements:	3.5 L/s at 1 103 kPa flowing pressure at eductor inlet	1.9 to 2.5 L/s at 276 to 689 kPa flowing pressure at eductor inlet
Foam-Expansion Ratio:	500 to 1	Varies from 500 to 1 to 700 to 1, depending on water pressure and flow
Foam Concentrate:	Approximately 2%	Approximately 2% at optimum conditions
Foam Output:	1.3 to 1.7 m^3/s	1.3 to 1.5 m^3/s

Eductor can be adjusted to meter foam concentrate from 1 to 6%. Eductor can be attached to the foamaker or in-line. Quick acting and manoeuverable by two men.

Mine Model Foamaker Generator

	Model A Foamaker	Model B Foamaker
Water Requirements:	1.9 L/s at 207 kPa inlet pressure	1.9 L/s at 207 kPa inlet pressure
Foam Output:	1.4 m^3/s	1.9 m^3/s

This foamaker is built for mine service and can operate unattended.

Model 6000 Foamaker Generator

Water Requirements:	6.3 L/s at 1 103 kPa flowing pressure at eductor inlet	3.2 L/s at 552 kPa at eductor
Foam Expansion Ratio:	600 to 1	850 to 1
Eductor:	-	Pre-set at factory to give 2%

The eductor can be adjusted to meter foam concentrate from 1 to 6%.
The eductor can be attached at the foamaker or in-line.
This unit can be towed to any location by the use of a trailer or pickup truck.

Mini-X Foamaker

Can produce 0.4 m^3/s with a 1.4 L/s eductor located on a fire truck.
Lightweight, portable and can be operated by one man.
Designed for connection to a 38 mm (1.5 in) hose.
Maximum operating pressure at foamaker: 552 to 689 kPa.
Maximum hose length: 30 m (98 ft).
Line pressure at eductor: 896 to 965 kPa.
Effective at 3.0 to 3.6 m (10 to 12 ft).

STATUS OF DEVELOPMENT AND USAGE – Commercially available products designed for application to hazardous materials spills.

PERFORMANCE – Vapour Suppressing Foams.

AVAILABILITY AND COMMERCIAL INFORMATION –

U.S. Manufacturer:

MSA Research Corporation
Evans City, PA 16033
U.S.A.
Telephone (412) 538-3510
Contact: Mr. C. H. Staub
or Mr. R.M. Hiltz

Canadian Manufacturer:

MSA Canada
148 Norfinch Drive
Downsview, Ontario
Canada
M3N 1X8
Telephone (416) 667-9400

OTHER DATA – Ultrafoam Concentrate is commonly used with these foamakers.

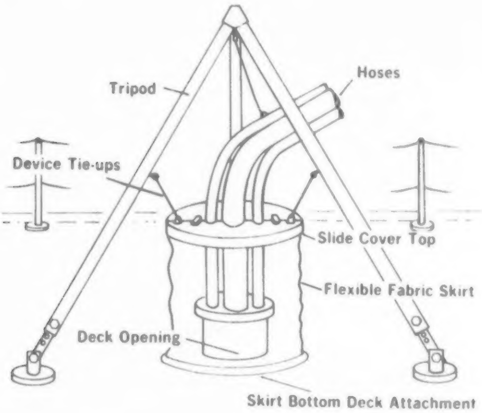
Reference: Manufacturer's Literature.

PROTOTYPE VAPOUR REDUCTION DEVICE (VRD) **No. 28**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
*						

DESCRIPTION – Prototype developed for the U.S. Coast Guard. The VRD system consists of a flexible "bag" which is secured around deck openings to contain vapours during off-loading procedures.



OPERATING PRINCIPLE – A tripod is used to support the barrel-like cover over the opening. Velcro strips on a magnetic mat are placed on deck. VRD base is lowered over the opening and Velcro strips around its base form a seal with strips on deck. VRD lid is then placed over the base and attached. It incorporates an adjustable opening permitting the insertion of "ADAPTS" piping while maintaining an effective seal.

PHYSICAL SPECIFICATIONS – Dimensions not documented.

Top:	Stainless Steel
Skirt:	Viton-coated Dacron
Slide Top:	Teflon

OPERATING SPECIFICATIONS – Deck Openings which may be accommodated: from: 318 mm (12.5 in) diameter flush deck Butterworth openings; to: Raised cargo hatches with coamings 762 mm (30 in) in diameter and 1270 mm (50 in) in height.

May be used directly with "ADAPTS" (see entry no. 116).

STATUS OF DEVELOPMENT AND USAGE – Prototype device which has undergone limited testing.

PERFORMANCE – Tests by the U.S. Coast Guard using heptane as a representative vapour determined that the VRD could keep vapour concentrations around the device down to about 1 ppm.

AVAILABILITY AND COMMERCIAL INFORMATION –

U.S. Coast Guard Research and Development Center
Avery Point
Groton, CT 06340 U.S.A.
Contact: Mr. D.L. Motherway

OTHER DATA – None obtained.

Reference: Motherway, D.L., H.W. Sites, R.S. Hamel, and F. Cooney, U.S. Coast Guard: "Development of a Vapor Reduction Device for Reducing Toxic Vapors During Emergency Off-loading Operations", Proc. 1980 Nat. Conf. on Control of Hazardous Materials Spills, pp. 322-326 (1980).

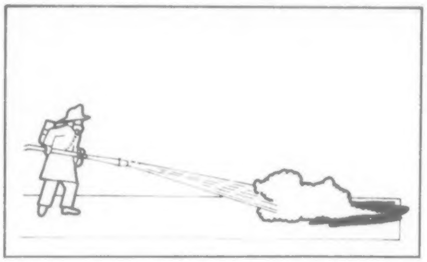
PRODUCT VAPOUR SUPPRESSING FOAMS - GENERAL LISTING **No. 29**

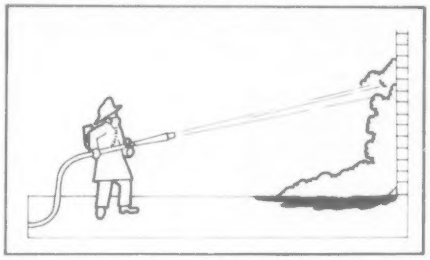
APPLICABILITY

Gas	Liquid Sol	Liquid Fl	Liquid Sk	Solid Sol	Solid Fl	Solid Sk
*	*	*	*			

Applicable to vapours rising from a pool of spilled liquid.

DESCRIPTION – A range of foams that can be used to control the vapour hazard from certain classes of hazardous materials through the formation of a continuous layer of bubbles or a thin film.





OPERATING PRINCIPLE – The foam blanket can temporarily reduce the vapour concentration above the spill surface, decrease the evaporation rate, provide a barrier to thermal or solar radiation and, in some cases, inhibit ignition or flame propagation if ignition does occur. Low expansion foams appear to mitigate a spill by forming a barrier to vaporization; high expansion foams appear to engulf the vapours, thereby reducing the vapour concentration directly above the foam layer.

WARNING: SOME FOAMS ARE NOT INTENDED FOR USE ON FIRES UNDER ANY CIRCUMSTANCES. CHECK BEFORE USING.

PHYSICAL SPECIFICATIONS –

Lorcon Foams (fire-fighting foams)

1) Lorcon Pyrosol - 3/6%

Specific gravity @ 20°C	1.015
pH @ 20°C	7.5
Viscosity	"pseudo-plastic solution"
Packaging	20 L (5.3 U.S. gal) plastic pail weighing 22 kg (48 lb) 208 L (55 U.S. gal) plastic-lined steel drum weighing 236 kg (520 lb)
Storage Temperature:	1.7 to 48.9°C (35 to 120°F)

2) Lorcon Full-Ex Multi-Expansion and Mid-Ex Medium Expansion

Specific gravity @ 20°C	1.01
pH @ 20°C	7.5
Viscosity @ 20°C	15×10^{-6} m^2/s
Packaging	20 L (5.3 U.S. gal) plastic pail weighing 22 kg (48 lb) 208 L (55 U.S. gal) plastic-lined steel drum weighing 236 kg (520 lb)
Storage Temperature:	1.7 to 48.9°C (35 to 120°F)

3) Lorcon Fluoroprotein

The company's regular and fluorinated protein foams are available as 3% and 6% concentrates in regular and low temperature forms.

	3%	6%	3% LT	6% LT
Specific gravity @ 20°C	1.135	1.150	1.110	1.120
pH @ 20°C	6.9	6.9	6.9	6.9
Viscosity ($m^2/s \times 10^6$)	25	18	35	18
Packaging	all available in 20 L (5.3 U.S. gal) plastic pail weighing 24.0 kg (53 lb) or as 208 L (55 U.S. gal) mild steel drum weighing 260.8 kg (575 lb)			
Storage Temperature	-6.7 to 37.8°C (20 to 100°F)		-28.9 to 37.8°C (-20 to 100°F)	

4) Other Lorcon Foams

In addition to Regular Protein, other Lorcan foams include Aqueous Film-Forming Foam (AFFF) and Training Foam Concentrate.

3 M Foams (fire fighting foams)

1) 3 M Light Water AFFF/ATC (ATC) Foam (3%/6% concentrate)
Specific gravity @ 25°C (77°F): 1.022

pH @ 25°C (77°F):	7.8
Viscosity: 4.4°C (40°F):	3.22×10^{-3} m^2/s
25 °C (77°F):	2.29×10^{-3} m^2/s
Packaging:	20.4 kg (45 lb)/ 19 L (5 U.S. gal) pail 236 kg (520 lb)/ 208 L (55 U.S. gal) drum
Storage Temperature:	1.7 to 49°C (35 to 120°F)

Note: AFFF = aqueous film-forming foam
ATC = alcohol type concentrate

2) 3 M Light Water AFFF Foam

	6%	3%
Specific gravity @ 25°C	1.012	1.055
pH at 25°C:	7.5	7.5
Viscosity: @ 4.4°C:	4.8×10^{-6} m^2/s	16.3×10^{-6} m^2/s
@ 25 °C:	2.4×10^{-6} m^2/s	7.5×10^{-6} m^2/s
Packaging, Storage Temperature:	Unspecified	

MSA Foams (fire fighting foams)

1) MSA Ultrafoam (high and low expansion) Type V
(Standard Grade)

- Density: 9.7×10^2 kg/m^3 (liquid)
- pH: 6.5 to 7.0
- Viscosity: 12×10^{-6} m^2/s
- Cloud point: 4°C
- Colour: Clear
- Packaging: 19 L plastic can weighing 19 kg
  113 L plastic lined steel drum weighing 112 kg
  208 L plastic lined steel drum weighing 204 kg

2) Ultrafoam SW

Formulated for salt water to -17.8°C (0°F), physical properties unspecified.

3) Ultrafoam Zero F and Super Grade

Formulated for fresh water, good to -17.8°C (0°F) and (0°C) 32°F, respectively, physical properties unspecified.

National Foam Foams

1) Hazmat NF Number 1 (for alkaline spills)
(Not for use on fires)

Specific gravity @ 25°C	0.950 to 1.050
pH	7.8 to 8.0
Viscosity @ 25°C	5 to 20 x 10^{-6} m^2/s
Packaging	Unspecified
Maximum Storage Temperature	49°C

2) Hazmat NF Number 2 (for acid spills)
(Not for use on fires)

Specific gravity @ 25°C	0.950 to 1.050
pH	4.5 to 5.0
Viscosity @ 25°C	10 to 20 x 10^{-6} m^2/s
Packaging	Unspecified
Maximum Storage Temperature	49°C

Note that Hazmat NF Numbers 1 and 2 replace their precursors CHF413 and CHF 784 (Chemical Hazard Foams), respectively.

Reference: Norman, E.C., "Vapor Mitigation by the Use of Foam: Case History and Large-Scale Outdoor Tests", National Foam System, Inc., Proceedings of the 1982 Hazardous Material Spills Conference, Milwaukee, WI, April 19-22 (1982).

3) Universal: 6 - 10% AFFF and Alcohol Resistant

Specific gravity at 25°C	0.98 to 1.02
pH	7.0 to 7.5
Viscosity	Unspecified
Packaging	19 L (5 U.S. gal) plastic pail weighing 20.4 kg (45 lb) 190 L (50 U.S. gal) plastic-lined steel drum weighing 210 kg (463 lb)

Universal CG foam is manufactured for shipboard use. Both polar solvent Universal foams replace the now discontinued National Foams product Aer-O-Water PSL.

4) National Foam also produces other foams applicable to flammable liquid materials:
Protein Based Types

Aer-O-Foam 3% Regular
Aer-O-Foam 6% Regular
Aer-O-Foam 3% Cold Foam
Aer-O-Foam 6% Cold Foam
Aer-O-Foam XL-3 - 3% Fluoroprotein (Cold Foam)
Aer-O-Foam XL-6 - 6% Fluoroprotein (Cold Foam)

Synthetic Types

Aer-O-Water 1 - 1% AFFF
Aer-O-Water 6 - 6% AFFF
Aer-O-Water Plus - 3% AFFF
(Available in Cold Foam)
High Expansion - 1 1/2 % to 3% Syndet

Please consult the manufacturer's literature for specifications pertinent to individual products.

Rockwood Systems Corp. Foams (fire fighting foams)

1) Aquafoam Omni 3%/6% AFFF

Specific gravity @ 25°C	0.98 to 1.02
pH	7.0 to 8.5
Viscosity @ 25°C	20 to 30 x 10^{-6} m^2/s
Packaging	18.9 L (5 U.S. gal) plastic pail weighing 20 kg (45 lb) 208 L (55 U.S. gal) lined metal drum weighing 260 kg (570 lb)
Storage Temperature	1.7 to 65.6°C (35 to 150°F)

This product replaces Rockwood Alcohol (All Purpose) Foam.

2) Fluoroprotein Foam: Super-Pro 3% and 6%

Specific gravity @ 20°C	1.16
pH	6.8 to 7.5
Viscosity @ 21.1°C (70°F)	45 x 10^{-6} m^2/s for 3% 18 x 10^{-6} m^2/s for 6%
Packaging	(see Aquafoam)
Storage Temperature	Unspecified

3) Protein Foam: Double Strength 3% and Regular Strength 6%

	3%	6%
Specific gravity @ 20°C	1.18	1.16
pH	6 to 7.5	6 to 7.5
Viscosity @ 20.6°C (69°F)	25.0 x 10^{-6} m^2/s	19.4 x 10^{-6} m^2/s
Packaging, Storage Temperature	As above	

4) Alcohol Resistant: 6% All Purpose Foam

Specific gravity @ 20°C	1.155
pH	less than 9.5
Viscosity @ 20°C	10 to 14 x 10^{-6} m^2/s
Packaging, Storage Temperature	As above

5) High-Expansion Foam: Jet-X 1% - 2.5%

Specific gravity @ 20°C	1.004
pH	6.8 - 7.0
Viscosity @ 20°C	6-10 x 10^{-6} m^2/s
Packaging, Storage Temperature	As above

6) AFFF Foam: Aquafoam 3% and 6%

	3%	6%
Specific gravity @ 25°C	1.023	1.018
pH @ 25°C	8.0	8.1
Viscosity @ 25°C	3.0 x 10^{-6} m^2/s	2.35 x 10^{-6} m^2/s
Packaging, Storage Temperature	As above	

Reference: Manufacturer's literature.

OPERATING SPECIFICATIONS – (based on manufacturer's literature)

Lorcon Foams

1) Lorcon Pyrosol - 3/6%

Formulated for hydrocarbon fire hazards at 3% concentration and polar solvent hazards at 6% concentration.
Freezing point: -2.2°C (28°F)
Usable temperature range 1.7 to 48.9°C (35 to 120°F)
Can be proportioned using most conventional hardware such as balanced pressure, pressure vessel, fixed or portable in-line (venturi) systems, etc.
Compatible with most dry chemicals.
Resists reignition and burnback.
Can be used with fresh or sea water.
Forms a sealing polymeric layer on polar solvents and a free-flowing aqueous film on hydrocarbons.
Expansion ratio varies between 4 and 10 to 1 depending upon the method of application.

2) Lorcon Full-Ex Multi-Expansion and Mid-Ex Medium Expansion

Formulated to fight hydrocarbon fires as well as automotive, brush, etc. fires.
Can be used with fresh or sea water.
Multi-Expansion foam can be proportioned at low, medium and high ratios; Medium-Ex can be proportioned at low and medium ratios.
Most conventional hardware can be employed to disperse foam.
Compatible with most foam-compatible dry chemicals.
Freezing point is -6.7°C (20°F)
Both foams are available as a single concentrate for use at various solution strengths depending upon expansion ratio selected and desired application.

3) Lorcon Fluoroprotein

Formulated for regular and low temperature applications.
Freezing point: -11.1°C, -17.8°C or -34.4°C
Compatible with most fluoroprotein concentrates, siliconized sodium bicarbonate, purple K and Super K dry chemicals.
Resists reignition and burnback.
Forms a cohesive, free-flowing blanket that clings to hot metal.
Applicable to vapour suppression and extinguishing fires of gasohol and hydrocarbon spills. Can be proportioned using most conventional equipment.

4) Other Lorcon Foams
Consult the manufacturer's literature.

3 M Foams

1) 3 M Light Water AFFF/ATC (ATC) Foam: 3%/6% Concentrate

Freezing Point: -2.2°C (28°F)
Minimum Use Temperature: 1.7°C (35°F)
Slight eye and skin irritant; non-toxic.
Biodegradable; can be treated in biological treatment systems.
Designed for protection of water-soluble polar solvents (eg. acetone, ketones) and water-insoluble hydrocarbon flammable liquids.
Recommended for use in a wide variety of foam application devices, such as non-aspirating sprinklers, water spray and fog nozzles.
Can be injected below liquid level of a burning petroleum storage tank.

2) 3 M Light Water AFFF Foam

	6%	3%
Minimum use temperature	1.7°C	-18°C
Freezing Point	-4°C	-26°C

Non-toxic, non-corrosive, biodegradable.
Compatible with other dry chemical agents and CO_2.
Designed for protection of both water-miscible polar solvents and hydrocarbon flammable liquids.
Provides a vapour seal which extinguishes the fire and prevents reignition.
Freeze-thaw cycling may cause slight stratification of the foam liquid which may be overcome by agitation.
Can be used with foam equipment and standard water/fog nozzles and eductors.
Can be injected below the liquid level of a burning petroleum storage tank.

MSA Foams

1) MSA Ultrafoam (high and low expansion) Type V (Standard Grade)

Pour point: -2°C
Soluble in cold water.
Storage stability: Indefinite @ 66°C in approved storage.
Biodegradable, non-corrosive.
Can be used in fixed or portable high-expansion foam-generating equipment and low expansion nozzles of any manufacturer.
With low-expansion foam nozzles, it can produce 20 to 1 volume of foam.
Can be stacked high without bubble collapse.

Reference: Manufacturer's Literature, personal communication, Mr. A. Paterson, Lorcon Inc. (March 23, 1982), Mr. Brack, Levitt-Safety (March 23, 1982).

2) Ultrafoam SW, Zero F and Super Grade

	SW	Zero F	Super Grade
Water Type	Salt	Fresh	Fresh
Minimum Operating Temperature	-17.8°C	-17.8°C	0°C
Other Characteristics	Generally as above		

National Foam Foams

1) Hazmat NF Numbers 1 and 2

NOT FOR USE ON FIRES.
Number 1 designed for alkaline spills and Number 2 intended for acidic materials spills.
Freezing point -4.0°C (25°F).
Minimum usable temperature 0°C.
Cannot be used on materials which react vigorously with water (e.g., oleum, hydrogen cyanide, chlorosilanes, etc.).
Liquid concentrate should be proportioned at 6% with fresh water using MPW nozzle and proportioner of any manufacturer to yield an expansion ratio exceeding 15:1.
Dilute to 0.01% concentration of foam before discharge of foam only to sewage facilities.
Store Hazmat NF Number 2 in stainless steel or fiberglass-reinforced polyester (FRP) containers.

Reference: Manufacturer's literature; Section XIV, Controlling Hazardous Vapors, received (November 7, 1983).

2) Universal: 6-10% AFFF and Alcohol Resistant

Designed for use on hydrocarbon fuels or polar (alcohol type) fuels.
Can be applied either through air-aspirating devices (polar fuels or hydrocarbons) or non-aspirating devices (hydrocarbons only).
May be plunged into fuel or applied to fires by subsurface (base injection) foam makers (hydrocarbons only).

May be used with fresh or sea water.
Use at 3% proportioning on hydrocarbons and 6% on polar fuels.
Minimum usable temperature 1.6°C.
Biodegradable, non-toxic.
Recommended storage container 0.48 cm (3/16 in) mild steel or 304 stainless steel.
Universal CG is manufactured for shipboard use.

3) Other National Foam Products

Consult the manufacturer's literature for data on specific product types within the following groups:

Aer-O-Foam XL Fluoroprotein Liquids
Aer-O-Foam Regular Liquids
Aer-O-Water Liquids (AFFF)
High Expansion Foam (Syndet)

Rockwood Systems Corp. Foams

1) Aquafoam Omni 3%/6% AFFF

Intended for both polar solvent (mix in 6% concentration) and hydrocarbon (at 3% concentrations) fires.
Low toxicity, non-corrosive and chemically stable.
Compatible with dry chemical agents.
Can be proportioned or premixed using fresh or salt water.
6% solution concentrate utilizes Type II application (foam partially submerged).
3% concentrate delivered directly onto burning liquid - Type III application.

2) Fluoroprotein Foam: Super-Pro 3% and 6%

Designed specifically for hydrocarbon fires.
Used where foam is plunged into burning fuels or injected below the fuel surface.
Compatible with dry chemicals.
Concentrate can be used with fresh or salt water.
Pour point of 3% is -3.9°C (25°F) and of 6% is -6.7°C (20°F).
Formulated to resist hydrocarbon saturation.
Designed for use with foam hardware of any manufacturer.

3) Protein Foam: Double Strength 3%; Regular Strength 6%

Both concentrates can be mixed with fresh or salt water. Low expansion foam designed for flammable liquid fires.
Formulated to be heat-resistant and smooth flowing.
Pour point of 3% concentrate is -26.1°C (-15°F) and of 6% is -6.7°C (20°F).

4) Alcohol Resistant: 6% All-Purpose Foam

Developed specifically for water-soluble flammable liquids. Intended for fires involving alcohols, ketones, esters and other polar solvents.
Concentrate should be mixed with water and aspirated; preparing pre-mix foaming solutions is not possible since reaction of concentrate with water proceeds rapidly. Should be applied gently to burning surface so that protective barriers surrounding bubble walls remain intact.
Pour point is -22.8°C (-9°F).

5) High-Expansion Foam: Jet-X 1% - 2.5%

Pour point: -2°C
1 L (0.3 U.S. gal) of foam solution produces 100 to 1000 L (26 to 264 U.S. gal) of foam.
Can float on LNG and hydrocarbons.
Can separate fire from fuel and extinguish hot hydrocarbon fires.
Capable of being stacked "hundreds of feet high" and totally flooding the area.
Can extinguish horizontal and vertical running fires.
Non-hazardous to people entrapped in it.
Can be used as a vapour suppressant.

6) AFFF Foam: Aquafoam 3% and 6%

Pour point of both concentrates is -1.1°C (30°F).
Designed primarily for aircraft crash rescue work and on flammable liquid hydrocarbon fires.
Formulated with wetting agent characteristics to make it applicable to ordinary combustibles.
Compatible with dry chemical agents.
Designed for rapid spreading as a vapour-suppressing film on fuel surfaces.
Non-corrosive, bio-degradable.
Designed to quickly drain from foam bubble to solution thus maximizing film and providing burnback resistance.

STATUS OF DEVELOPMENT AND USAGE – All foams addressed are available as commercial products. Except as noted, they have been largely formulated and have been widely utilized to extinguish fires resulting from the ignition of accidental spillages of flammable liquids. Their use also includes the mitigation of the effects of vapours from hazardous materials spills. Investigation of the latter situation involves various ongoing research and development programs.

PERFORMANCE – As an overall guide to the types of foams available and their potential uses, the following summary table has been prepared. General use guidelines as well as reference to foam types and specific chemicals are presented following this table.

Foam Type	Formulation	Application	Comments
Protein-based:			
1) Protein	hydrolyzed protein with additives to retard biodegradation	flammable liquid hydrocarbons	low expansion; provide short-term control; good heat resistance, cohesiveness and stability
2) Fluoroprotein	protein plus fluorinated surfactants	flammable liquid hydrocarbons	low expansion; short-term control; resist hydrocarbon saturation and burnback
3) Alcohol	alcohol-based protein foam	flammable polar solvents	low expansion; short-term control; stable with some alcohols, ketones esters, etc.

Generally, protein-based foams are low expansion and add water at a relatively fast rate particularly to reactive liquefied gases and liquids. Higher water drainage does not favour the mitigation of vapours although alcohol foams are stable against polar, low molecular weight liquids such as acetone. These foams have been developed primarily for fire control.

Foam Type	Formulation	Application	Comments
Surfactant-based:			
1) Low Expansion	synthetic detergents	flammable liquid hydrocarbons	short-term control; more suited to vapour control in higher winds
2) High Expansion	synthetic detergents	flammable liquid hydrocarbons	longer-term control; low water drainage; best for reactive liquefied gases and liquids; use in low winds (<4.5 m/s)
3) Aqueous Film-Forming Foam (AFFF)	fluorosurfactants	flammable liquid hydrocarbons	designed for quickly extinguishing fires; vapour control is satisfactory with some substances
4) AFFF/Alcohol	fluorosurfactant plus alcohol concentrate	flammable polar solvents and hydrocarbons	low expansion; designed for quick fire control; avoid water-reactive liquids although low water drainage indicated by manufacturer; vapour control should be satisfactory with a range of substances
5) Alkaline-Resistant	surfactant plus additives	alkaline materials not on fire	medium expansion; slow drainage rate claimed; foam stable with specified materials for vapour control
6) Acid-Resistant	surfactant plus additives	acidic materials not on fire	medium expansion; slow drainage rate claimed; designed for vapour control of spilled acidic liquids

For the most part, surfactants have been developed for fire control and are suitable for both low (10:1) and high (100:1) expansion applications except as indicated. High expansion foams require less water, exhibit lower vapour concentrations above the foam blanket but are more influenced by wind (above 4.5 m/s), rain and temperature (above 21.1°C (70°F)).

General Guidelines to Foam Use

For liquefied gases heavier than air, foams may be of little value.
For liquefied gases lighter than air, high expansion foams may provide reasonable vapour mitigation.
For nonpolar liquids not water-reactive, any high quality foam cover affords control.
High expansion foams generally result in greater long-term control than low expansion foams, particularly in water-reactive materials.
For polar liquids, alcohol and polar AFFF products remain stable longer than other types.
Generally, choose foams to control vapours originating from individual substances by determining if applicability to the material in question is known.

Foam Capability in Specific Hazardous Materials

The following matrix of foam capabilities was derived by MSA Research Corporation under sponsorship of the U.S. Environmental Protection Agency.

AVAILABILITY AND COMMERCIAL INFORMATION –

	Canada	U.S.A.
Lorcon Foams:	Wormald CDN Inc. 2421 Holly Lane Ottawa, Ontario K1V 7P2 Telephone (613) 526-0435 Contact: Mr. George Cowan	Wormald U.S. Inc. 1 Stanton Street Marinette, WI 54143 Telephone (715) 735-7411 Contact: Dr. J.F. Riley
3 M Foams:	3 M Canada Inc. Fire Protection Systems Division P.O. Box 5757 London, Ontario N6A 4T1 Telephone (519) 451-2500 Contact: Mr. K. Schoenroth	3 M Company 3 M Center St. Paul, MN 55101 Telephone (612) 733-0466
MSA Foams:	MSA Canada 148 Norfinch Drive Downsview, Ontario M3N 1X8 Telephone (416) 667-9400	MSA Research Corporation Evans City, PA 16033 Telephone (412) 538-3510 Contact: Mr. C.H. Staub
National Foam Foams:	Distributor: Levitt-Safety Ltd. 33 Laird Drive Toronto, Ontario M4G 3S9 Telephone (416) 425-8700	National Foam Systems Inc. 150 Gordon Drive Lionville, PA 19353 Telephone (215) 363-1400 Contact: Mr. S.E. Elinsky or Mr. E.C. Norman
Rockwood Foams:	—	Rockwood Systems Corporation 80 Second Street South Portland, ME 04106 Telephone (207) 799-3341

OTHER DATA – Foam application equipment is generally available from foam manufacturers. One listing only has been included in this survey (Entry No. 27) due to time constraints associated with this project. It indicates a typical range of foam dispensing hardware.

References: Bennett, G.F., F.S. Feates and I. Wilder, Hazardous Materials Spills Handbook, McGraw-Hill (1982).

Gross, S.S. and R.H. Hiltz, "Project Summary Evaluation of Foam for Mitigating Air Pollution from Hazardous Spills", EPA-600/S2-82-029 (July, 1982).

Gross, S.S. and R.H. Hiltz, "Evaluation of Foams for Mitigating Air Pollution from Hazardous Spills", EPA-600/2-82-029, Cincinnati, OH (June, 1982) and project summary (July, 1982).

FOAM CAPABILITIES

		Overall Recommendation	Surfactant -Low Expansion	Surfactant -High Expansion	Protein	Fluoroprotein	Alcohol	AFFF
Organics-Aliphatic								
Acids	- Acetic Acid	ND	ND	ND	ND	ND	ND	ND
	- Caproic Acid	ND	U	ND	ND	ND	ND	ND
Alcohols	- Amyl Alcohol	ND	U	U	ND	ND	ND	ND
	- Butanol	R	E-	E-	E-	E-	A+	E-
	- Butyl Cellosolve	ND	ND	ND	U	ND	ND	ND
	- Methanol	R	E-	E-	E-	E-	A+	E-
	- Octanol	R	U	U	U	U	U	ND
	- Propanol	R	E-	E-	E-	E-	A+	E-
Aldehydes & Ketones	- Acetone	R	E-	E-	E-	E-	A+	E-
	- Methyl Butyl Ketone	R	E-	E-	U	ND	A+	ND
	- Methyl Ethyl Ketone	R	U	U	U	ND	A+	ND
Esters	- Butyl Acetate	ND	U	U	U	U	ND	ND
	- Ethyl Acetate	ND	U	U	U	U	ND	ND
	- Methyl Acrylate	ND	U	U	ND	U	ND	ND
	- Methyl Methacrylate	ND	U	U	ND	U	ND	ND
	- Propyl Acetate	ND	U	U	U	U	ND	ND
Halogenated	- Butyl Bromide	ND	U	U	ND	ND	ND	ND
	- Methyl Bromide	ND	U	U	ND	ND	ND	ND
	- Tetrachloroethane	ND	U	U	ND	ND	ND	ND
Hydrocarbons	- Heptane	R	C+	B+	B+	B+	A+	C+
	- Hexane	R	C+	B+	B+	B+	A+	C+
	- Octane	R	C+	B+	B+	B+	A+	C+
Nitrogen Bearing	- Dimethyl Formamide	ND	U	E-	ND	ND	ND	ND
Organics-Aromatic								
Hydrocarbons	- Benzene	R	C+	B+	B+	B+	A+	C+
	- Tetrahydronaphthalene	R	U	U	U	ND	ND	U
	- Toluene	R	C+	B+	B+	B+	A+	C+
Organics-Alicyclics	- Cyclohexane	R	B+	A+	B+	B+	C+	C+
Organics-Industrial	- Gasoline	R	C+	B+	B+	B+	C+	C+
	- Kerosene	R	C+	B+	B+	B+	A+	C+
	- Naphtha	R	C+	B+	B+	B+	C+	C+
	- Paint Thinner	R	C+	B+	B+	B+	A+	C+
Organics-Cryogens	- Liquefied Natural Gas	R	C-	A+	E-	E-	E-	E-
Inorganics	- Silicon Tetrachloride	R	E-	A+	E-	E-	E-	E-
	- Sulphur Trioxide	R	E-	A+	E-	E-	E-	E-
Inorganics-Cryogens	- Ammonia	R	C+	A+	C+	C+	E-	C+
	- Chlorine	R	C+	C+	C+	C+	E-	E-

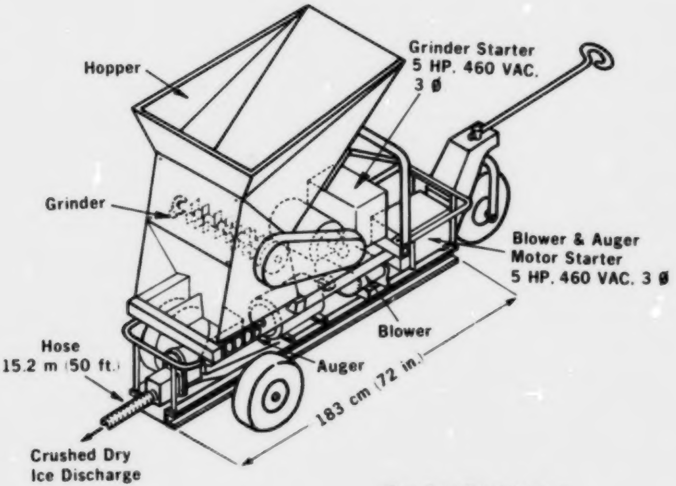
U	Limited data available - capabilities uncertain
ND	No data
R	Foam use recommended over spill
A+	Best foam formulation
B+	Next best foam formulation
C+	Acceptable in some situations
E-	Unsuitable foam formulation

CONCEPT VAPOUR SUPPRESSION BY ARTIFICIAL COOLING No. 30

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
*	*	*	*			

DESCRIPTION – Concept. A crusher-pneumatic system distributes dry ice over a spilled volatile chemical to lower its temperature thereby reducing the downwind concentration. The concept is primarily suitable for controlling toxic vapours rather than posing a flammable or explosive hazard.



Dry Ice Distributor

OPERATING PRINCIPLE – Coolant is mixed directly with the spilled chemical to lower its temperature thus reducing its equilibrium vapour pressure.

PHYSICAL SPECIFICATIONS – The prototype crusher-pneumatic system developed for the distribution of dry ice consists of:

MSA Rockduster: Blower, hopper, auger feed screw, and discharge hose driven by an explosion-proof electric motor (see the "Solids Broadcaster" listed in this survey).

Fitted with Model 4G Shredder/Grinder (W.W. Grinder Company, Wichita, Kansas):

Shredder/Grinder (W.W. Grinder Co., Model 4-G)

Power Train		0.67 kW (9 hp) at 3200 rpm
Hopper Size	- Mill	43.2 x 43.2 cm (17 x 17 in)
	- Top	89 x 91.5 cm (35 x 36 in)
Screen Opening	5.1 cm (2 in)	
Mill Speed		Max. - 2500 rpm
		Min. - 600 rpm

System Modifications:

Gas-powered motor of the crusher was replaced by an electric explosion-proof motor for safety reasons.

Electric motors are powered by a remote diesel electric generator.

Auger replaced by a 51 mm (2 in) uniform-pitch auger to reduce blockage.

Crusher speed reduced from 900 rpm to 600 rpm to reduce the amount of fine particles.

OPERATING SPECIFICATIONS –

Throughput 13.6 kg/min (30 lb/min).
Conversion of dry ice through system (output/input): 50% due to sublimation.
25 x 25 x 2.5 cm (10 x 10 x 1 in) dry ice blocks were available.
Pneumatic Operating Capacity: 2.3 m^3 (80 ft^3) per minute of air at 30.5 m (100 ft) per second through a 38 mm (1.5 in) hose.

STATUS OF DEVELOPMENT AND USAGE – No indication was received of further research and development of these concepts by the U.S. EPA beyond the data reported here.

PERFORMANCE – A feasibility study evaluated four potential coolants: water ice, dry ice, liquid carbon dioxide, and liquid nitrogen. Preliminary evaluations were based on laboratory studies and were followed by a limited scaled-up test using dry ice.

Water ice did not cool sufficiently. Liquid nitrogen and carbon dioxide required large quantities of material and produced a dense obscuring cloud hampering cleanup operations.

Dry ice was found to be the most versatile coolant; it is easier to handle and readily available at a reasonable cost. A prototype unit was developed consisting of a crusher and pneumatic conveyor to crush and distribute the dry ice onto the spill.

757 L (200 U.S. gal) of diethyl ether pooled over an area 7.6 x 3 m (25 x 10 ft) was cooled to -60°C (-76°F) by approximately 204 kg (450 lb) of dry ice distributed at a rate of 13.6 kg/min (30 lb/min). The free spill vapour concentration in the vicinity of the spill was reduced by an order of magnitude. The pool temperature was still below -10°C (14°F) two hours after dry ice discharge was terminated. The day of testing was clear with 32 km/h (20 mph) winds and 21°C (70°F) ambient temperatures.

AVAILABILITY AND COMMERCIAL INFORMATION –

Feasibility study completed by:

J.S. Greer, S.S. Gross, R.H. Hiltz and M.J. McGoff MSA Research Corporation Evans City, PA 16033 U.S.A. Contract No. 68-03-2648	for:	John E. Brugger, Project Officer Municipal Environmental Research Laboratory Office of Research and Development U.S. Environmental Protection Agency Cincinnati, OH 45268 U.S.A. Telephone (201) 321-6634

OTHER DATA – The low solubility of CO_2 in most materials is considered to pose little interference with ultimate disposal procedures such as containment or incineration.

Carbon dioxide gas can pose a life hazard (asphyxiation) to personnel due to the displacement of oxygen. Standby self-contained breathing apparatus is recommended while distributing the dry ice.

Sublimation of dry ice at the surface of the spill can exaggerate vapour release negating the cooling effect of the dry ice.

Reference: J.S. Greer et al., "Modification of Spill Factors Affecting Air Pollution, Vol. 1: An evaluation of Cooling as a Vapour Mitigation Procedure for Spilled Volatile Chemicals", MSA Research Corporation, EPA Report 600/2-81-214 (September, 1981).

2 REMOVAL

2 REMOVAL

2.1 Removal from Land

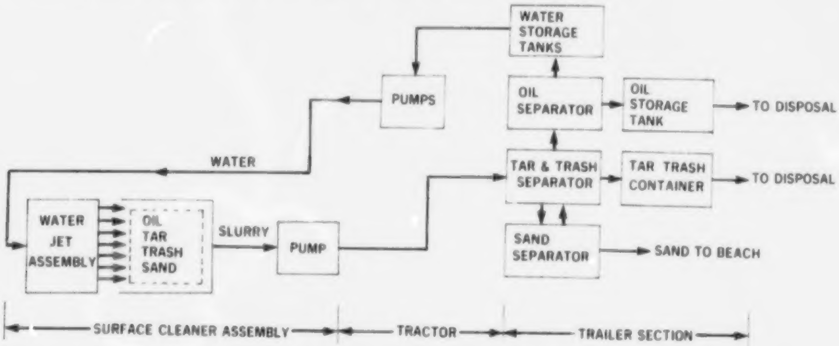
PRODUCT MOBILE SURFACE CLEANER **No. 31**

APPLICABILITY

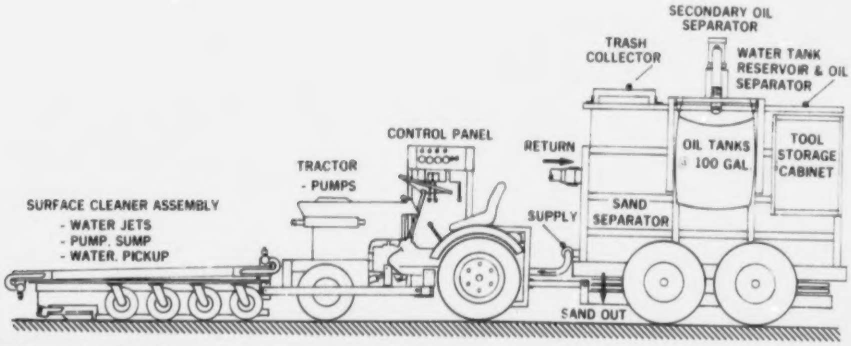
Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*	*	*	*

Note: Applicable to liquids or solids sorbed into or mixed with soils.

DESCRIPTION – A mobile system, consisting of a hydraulic surface cleaner, tractor and separation trailer, developed for cleaning oil spills from beaches.



SCHEMATIC - MOBILE BEACH CLEANER



OPERATING PRINCIPLE – A surface cleaner assembly, pushed by a small tractor, agitates the soil surface with water jets to form a slurry of contaminated soil which is propelled to the inlet of a special suction pump. The slurry is pumped to a trailer in the rear of the tractor where debris is separated and collected in flexible bags for disposal. Soil (sand) settles out in a separator and can be returned to the land. Oil is skimmed from the water and pumped to two storage tanks adjacent to the separation tank. The water is returned to the jets of the surface cleaner.

PHYSICAL SPECIFICATIONS – (Model 707):

Surface Cleaner Assembly

Steel outer frame mounted on eight swivel tires.
Width of cleanup area: 167 cm (66 in).
Weight: 454 kg (1000 lb) max.
Wash Assembly: Mounted inside outer frame and hydraulically adjustable by operator. Twelve low velocity water jets, high velocity water jets and sump pump (Briggs and Stratton motor).
Tractor (Optional. Other similar garden tractors can be used.)
Kubuta, diesel engine, four-wheel drive.
Control Panel mounted within convenient reach of operator. Controls pumps, separators and leveling.

Trailer Section

2650 L (700 U.S. gal) oil separator tank; translucent, corrosion-resistant material.
Trailer supported by four, low pressure tires and air springs to allow operator to level liquid in separator tank.

Overall Dimensions (Total three sections.)

Length	6.1 m (20 ft)
Width	2.1 m (7 ft)
Height (max.)	2.1 m (7 ft)

Shipping Weight (Total three sections.): 1360 kg (3000 lb)

Note: These values are typical of the Model 707. Comar builds the Mobile Surface Cleaner to suit the customer's specifications. Therefore, physical specifications can vary.

OPERATING SPECIFICATIONS – Operable by one person.

Average Speed: 1.6 km/h (1 mph)
Oil Pickup Rate: Approximately 190 L/min (3000 U.S. GPH), depending on soil conditions).
Sand Pickup: Approximately 0.25 mm (0.010 in)
Make-up water connection on sump pump.

STATUS OF DEVELOPMENT AND USAGE – Four units have been sold to major U.S. oil companies for approximately $95 000 U.S. (1984). Comar claims the Mobile Surface Cleaner is suitable for operation over various surfaces including sand, cobbled soil, grass, concrete and asphalt.

PERFORMANCE – No evaluation data available reflecting performance for oil or hazardous material spills.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Comar, Inc. (formerly Moorehead Engineering Co.)
P.O. Box 832676
Richardson, TX 75080
U.S.A.
Telephone (214) 238-7691

OTHER DATA – This system could be adapted for corrosive or volatile hazardous materials through appropriate changes in the material of construction of the piping, pumps, and tires; however, the efficiency may be limited as the only separation techniques employed are screening, sedimentation and flotation (skimming). Suggested modifications for separating soluble organics might include carbon adsorption, ion exchange, reverse osmosis or solvent extraction(1). Inorganics (primarily metals) could be separated by conventional wastewater treatment techniques such as precipitation, chelation or flocculation. (See also entry No. 80).

(1) Refer to Entry No. 33, "EPA SOLVENT EXTRACTION SYSTEM" for further insight into soil cleanup technology.

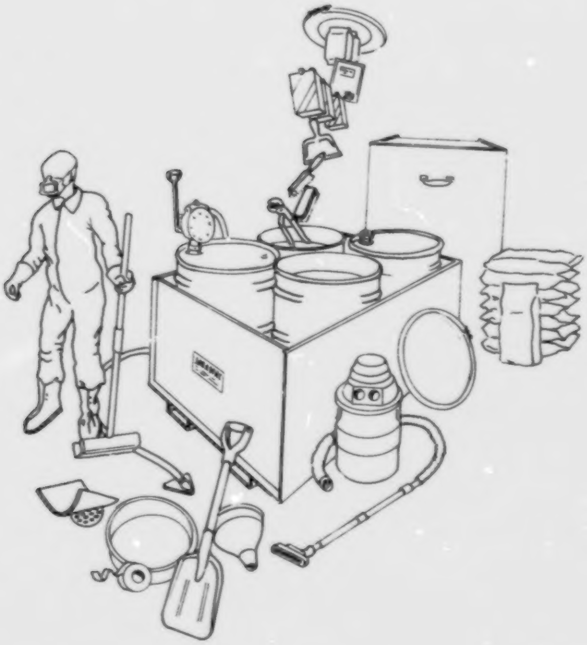
PRODUCT ENVIROPAC PCB REMOVAL KIT **No. 32**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
			*			

Applicable to PCBs.

DESCRIPTION – A U.S. EPA-approved palletized steel container designed to store PCBs and equipped to provide quick response capability for PCB spills or leaks.



OPERATING PRINCIPLE – The kit can be readily transported to a spill site to provide four persons with protective clothing and equipment to vacuum and/or adsorb and store PCB wastes in four drums approved for this purpose.

PHYSICAL SPECIFICATIONS –

Palletized steel container with cover:
1.2 x 1.5 m (4 x 5 ft)
Filled height of 89 to 101 cm (35 to 40 in)
Two float-actuated, battery-powered alarms to warn of excessive free fluid levels within.

(Optional) four 55 U.S. gal drums:
- 2 DOT-17E for liquid PCBs
- 2 DOT-17C for solid PCBs

Full drum indicator.
Bung tool.
110 Vac wet/dry vacuum system.
Hand-operated pump with 12 ft of hose.
Eight 11.4 kg (25 lb) bags of high capacity sorbent.
Drain stops.
Mineral spirits and trichloroethane for final cleanup.
Rags, shovel, broom, brush and pan.
Protective clothing for four people.
EPA-required PCB labels.
Instruction book.

OPERATING SPECIFICATIONS – The palletized container meets all U.S. EPA requirements for a diked, covered, PCB warehouse, provided the stored material is in proper drums and the unit is located above the 100 year flood elevation.

Saraspac units can be stacked to a maximum of 3 high.

STATUS OF DEVELOPMENT AND USAGE – Available as a commercial product. Documentation on spill usage not obtained.

PERFORMANCE – All components are standard, off-the-shelf items that should prove adequate for the removal of PCBs. User evaluation data were not obtained.

AVAILABILITY AND COMMERCIAL INFORMATION –

Environmental Container Corporation
P.O. Box 161
Delafield, WI 53018
U.S.A.
Telephone (414) 646-2480
Contact: J.A. Macdonald

Cost of SARASPAC-E: $1750 U.S. (Oct., 1983) F.O.B. Waukesha, WI, U.S.A.

OTHER DATA – Other Enviropac kits for the storage of PCBs include:

	Number of 55 U.S. gal Drums	
Enviropac Kit	Closed Top DOT-17E	Open Top DOT-17C
A	4	0
B	3	1
C(1)	0	0
D	0	4
F	2	2
G	1	3
CAPAC (2)	0	0

Notes: (1) The Enviropac-C should be filled with four, proper, customer supplied, 55 U.S. gal drums of either open or closed top style.

(2) The CAPAC, with 2.1 m^3 (75 ft^3) storage capacity, is a "no-drum" design for non-leaking PCB articles and equipment (e.g., capacitors).

SEC Inc. can provide transport, storage, disposal and recycle of PCB wastes.

References: Enviropac brochure No. 092381, "The PCB Full Service Company".

Enviropac product Bulletin No. 042981, "Saraspac-E PCB Emergency Environmental Protection Kit".

PROTOTYPE SOLVENT EXTRACTION SYSTEM No. 33

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – A mobile, prototype field-use system designed to strip a wide variety of spilled chemicals from excavated soils and sediments. The system is comprised of a vibrating screen classifier, water knife/soil scrubber, soaking unit, countercurrent chemical extractor, hydrocyclone separators/waste liquid recyclers, and air cleaners.

OPERATING PRINCIPLE – Contaminated soil is excavated and mechanically broken up. The spilled chemical is then stripped from a slurry of the soil particles through the use of water plus additives. This solvent is further processed to recover the spilled chemical. The clean soil may be returned to the excavation site.

PHYSICAL SPECIFICATIONS – (prototype)

Overall Dimensions: 9.8 x 2.4 x 2.4 m (32 x 8 x 8 ft)
Empty Weight: 6340 kg (14 000 lb)
Rotating water-knife drum screen soil scrubber: 6.4 x 1.4 m diameter (21 x 4 1/2 ft diameter)
Initial Spray Zone: 1.2 m (4 ft) long reinforced screen
Soaking Section: 4.6 m (15 ft) long
Rinsing Zone: 0.6 m (2 ft) long
Countercurrent chemical extraction system: four-tank system with mixers and slurry pumps, unspecified.
Rough screen feeder: 2.5 cm (1 in) mesh.

OPERATING SPECIFICATIONS –

Feed material size: $\leq$ 2.5 cm (1 in)
Slurry particle size: $\leq$ 2 mm
Nominal soil processing capability: 2.3 to 3.8 m^3/h (3 to 5 yd^3/h)
Water knife pressure: 414 kPa (60 psi)

Note: Maximum soil processing capability may reach 13.8 m^3/h (18 yd^3/h) for soil containing large amounts of larger free-flowing granular solids. A limiting factor is the capacity of the EPA-ORD mobile physical-chemical treatment system (see Entry No. 69) utilized to treat washing fluids for reuse. The floc-settle and sand-anthracite filtration unit now limits the processing rate to 2.3 to 3.8 m^3/h (3 to 5 yd^3/h) for many soils.

STATUS OF DEVELOPMENT AND USAGE –

A full-scale, field-use prototype system has been constructed and tested with objects greater than 2.5 cm (1 in) in size. It is ready for field demonstrations and further evaluation. Soils rich in organic matter can present problems in the extraction of certain hazardous substances.

PERFORMANCE – Laboratory tests were conducted that determined phenol could be efficiently removed from both organic and inorganic soils. PCB and arsenic were released less readily into the washing fluids. Representative test data are:

Table 1 Maximum Column Loadings

Contaminant	Organic Soil (mg/g soil)	Inorganic Soil (mg/g soil)
Phenol	453.2	48.3
Arsenic trioxide	5.0*	0.75*
PCB	25.6	3.0

* as arsenic (As).

Table 2 Effect of Washing on Large Particles+ (2 to 12.7 mm)

Soil	Test Time (min)	% Removal		
		Phenol	As_2O_3	PCB
Inorganic	15	97.9	28.9	21.4
	30	98.2	52.1	50.0
	60	98.8	42.2	21.4
	120	99.1	52.1	28.6
Organic	15	60.7	47.7	
	30	79.2	55.8	
	60	86.0	54.0	
	120	91.6	59.0	

Table 3 Solvent Extraction: Representative Single-Washing Tests*

Contaminant	Soil**	Solvent	Initial Soil Dose (mg/g dry soil)	% Removal	Supernatant Concentration (mg/L)	Residual Soil Concentration mg/g
Phenol	I	Water	48	98.6	1 190	0.68
	O	Water	452	77.8	17 600	100.4
		NaOH (pH 11)		88.4	20 000	52.5
As_2O_3	I	Water	0.75	42.7	16	0.43
		H_2SO_4 (pH 1)		85.3	32	0.11
	O	Water	5	75.0	375	1.25
		H_2SO_4 (pH 1)		85.0	425	0.75
PCB	I	Water	3	24.6	72	2.66
		1% Tween 80		37.5	110	1.88
	O	Water	26	48.3	418	13.2
		1% Tween 80		23.8	366	19.5

* Extractant to dry solids 10:1 (w/w); ** I = inorganic; O = Organic.

AVAILABILITY AND COMMERCIAL INFORMATION –

Contractor:
Rexnord, Inc.
Environmental Research Center
P.O. Box 2022
Milwaukee, WI 53201
U.S.A.
Contact: Mr. R. Scholz
Ms. K. Huibregtse

Sponsoring Agent:
Oil and Hazardous Materials Spills Branch
Municipal Environmental Research Laboratory-Ci
U.S. EPA
Woodbridge Avenue
Edison, NJ 08837
U.S.A.
Telephone (201) 321-6634
Contact: Dr. J.E. Brugger
Mr. R. Traver

OTHER DATA – Complete system requires auxiliary equipment (e.g., EPA-ORD physical/chemical treatment trailer) to process wastewater for recycling; confining and treating released gases and mists also sometimes required. Principal limiting constraint on soils treatability is high weight-percent clay content. Most inorganic compounds, almost all water-soluble/readily oxidizable organics, some partially water-miscible organics can be treated with water or water-plus-additive. Soil scrubbing speeds up release of chemicals from soils; extent to which the system has practical, cost-effective utility in a specific spill situation not yet determined; acceptable limits of residual concentrations in washed soil must be adopted by regulatory authorities.

References: Project Summary, "Mobile System for Extracting Spilled Hazardous Materials from Excavated Soils" (December, 1983), EPA-600/S2-83-100.

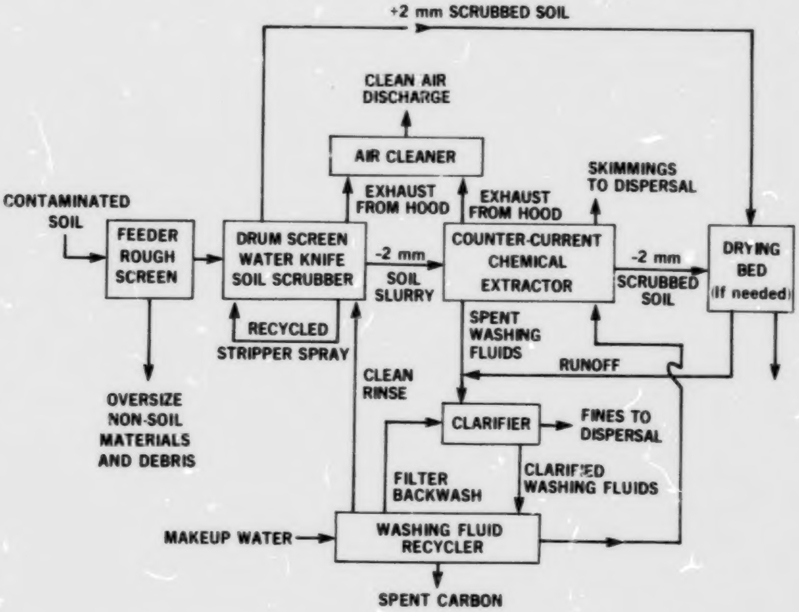
Huibregste, K.R., Scholz, R.C., Kastman, K.H., Rexnord Inc. and Soil Testing Services Inc.: "Development of a Mobile System for Extracting Spilled Hazardous Materials from Soil", Proc. 1980 Nat. Conf. on Control of Hazardous Materials Spills, pp. 134-140 (1980).

CONCEPT SUBSURFACE SOIL SURFACTANT **No. 34**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – A concept for the in-situ treatment of soils more than 0.6 m (2 ft) underground which are contaminated with slightly water-soluble and hydrophobic organics, or heavy metals.



OPERATING PRINCIPLE – Water and surfactant are injected into the soil, and the leachate recovered through a draw-down well or interceptor trench, submersible pump, or "French drains" located down gradient from the zone of contamination. The leachate is treated above ground using carbon adsorption or other chemical and/or physical treatment methods.

PHYSICAL SPECIFICATIONS – None obtained.

OPERATING SPECIFICATIONS – None obtained.

STATUS OF DEVELOPMENT AND USAGE – Concept under study.

PERFORMANCE – The results of a lab-scale study by JRB Associates showed that a 4% aqueous solution of non-ionic surfactants (2% Hyonic NP90 (Diamond Shamrock), 2% Adsee 799 (Witco Chemical)) was effective in removing high-boiling point Murban crude oil distillates. PCBs (transformer oil), and chlorophenol mixtures when percolated by gravity through a column of contaminated soil.

A Texas Research Institute (1982) study on surfactant-enhanced gasoline recovery from a large-scale model aquifer showed the percentage of gasoline removed increased from 6 to 83% when comparing a single surfactant application percolated down through the sand bed to daily application into the water table.

	% Contaminant Remaining in the Soil	% Contaminant in Flushed Leachate
Murban Distillates:		
Water Wash Only	85 to 100	< 0.002
Surfactant Wash	6 to 9	74 to 86
PCBs:		
Water Wash Only	88 to 97	0.01 to .004
Surfactant Wash	2 to 9	60 to 68
Chlorophenols:		
Water Wash Only	0.6 to 2	64 to 70
Surfactant Wash	0.1	70

AVAILABILITY AND COMMERCIAL INFORMATION –

Research by:

JRB Associates
8400 Westpark Drive
McLean, VA 22102
U.S.A.
Contact: W.D. Ellis
J.R. Payne

Prepared by:

Oil and Hazardous Materials Spill Branch
U.S. Environmental Protection Agency
Municipal Environmental Research Laboratory
Woodbridge Avenue
Edison, NJ 08837
U.S.A.
Contact: Anthony N. Tafuri, Technical Project Manager
EPA Contract No.: 68-01-3113, Task No. 29

OTHER DATA – Further testing (1984) of surfactant washing using a larger-scale 42.5 m^3 (1500 ft^3) Chemical Additive Treatment (CAT) tank (42 m^3 (1 483 ft^3) capacity) is planned for the EPA OHMSETT facility in Edison, NJ. The tests will focus on the quantity and type of surfactant used, and Total Organic Content (TOC), particle distribution, compaction, permeability, and moisture content of the soils used.

Reference: W.D. Ellis and J.R. Payne, JRB Associates, "Chemical Countermeasures for In-Situ Treatment of Hazardous Material Releases," Draft Final Report, Prepared for the Oil and Hazardous Materials Spills Branch, U.S. EPA, Municipal Environmental Research Laboratory, Edison, NJ (August 12, 1983).

PRODUCT TRITEK TRANSPORTATION EMERGENCY KIT **No. 35**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*	*	*	*

DESCRIPTION – Three self-contained cleanup kits designed for truck, train, or dock-related spills or leaks of hazardous liquids or solids.

OPERATING PRINCIPLE – Overpack drums are supplied with sorbents, personal safety equipment, hazard warning labels, and collection pails for immediate cleanup of small spills.

PHYSICAL SPECIFICATIONS – Kits include:

	TRITEK I	TRITEK III	TRITEK V
Overpack Drums 322 L (85 U.S. gal) w/gasket, ring and 16 mm (5/8") bolt	1	3	5
Spec. 37A Pails 19 L (5 U.S. gal)	2	3	5
Hazorb Absorbent Pillows 43 x 66 x 5 cm (17 x 26 x 2 in)	8	24	24
No. 2 Vermiculite 8.6 kg (19 lb)	1	3	5
Haz-mat Labels	24	72	120

	TRITEK I	TRITEK III	TRITEK V
Drum Liners 4 mil Polyethylene Bag	3	3	5
3 Piece Safety Suits Polyvinyl	2	2	2
Safety Goggles	2	2	2
Rubber Gloves (pair)	2	4	4
Half-face Respirators 3M brand for gas/vapour	2	2	2
Dust Masks (NOT FOR USE WITH TOXIC MATERIALS)	2	4	4
Safety Flashlight MESA & U.S. Coast Guard approved (w/batteries)	1	1	1

OPERATING SPECIFICATIONS – The kits are primarily designed for the recovery of small volumes of spilled liquids amenable to absorption by vermiculite and Hazorb (see section 2.4). No other means is provided to implement collection.

STATUS OF DEVELOPMENT AND USAGE – Commercial product consisting of off-the-shelf items assembled to comprise a cleanup kit.

PERFORMANCE – Documentation of use on spills of hazardous materials not obtained.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Triangle Resource Industries
14201 Laurel Park Drive
P.O. Box 370
Laurel, MD 20707
U.S.A.
Telephone (301) 953-9583 or
(301) 792-7507 or toll free
1-800-638-4440
Contact: Mr. Paul Watson

GSX Services Inc.
3527 Wadley Bottom Road
Laurel, MD 20707
Telephone: (301) 953-9583
Contact: Ruth Elwell

Cost ($U.S., 1983):

Tritek I	$249
Tritek III	$560
Tritek V	$825

OTHER DATA – Triangle Resource Industries is a service company providing emergency spill cleanup and recovery, laboratory support, and hazardous materials program management.

2.2 Skimming from Water

PRODUCT MECHANICAL SKIMMERS - GENERAL LISTING **No. 36**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
		*			*	

DESCRIPTION – A mechanical device designed for deployment in water to effect the recovery of floating contaminants.

OPERATING PRINCIPLE – Skimmers can be arbitrarily categorized into four main groups, according to their collection mechanisms, as follows:

1) Weir on Section Devices:

The material being recovered overflows a lip into a reservoir or is suctioned through openings (in a skimming head) positioned at the air/water interface. An onboard or remotely-operated pump causes an inward movement of the fluid. Several models of weir skimmers incorporate a hydroadjustable collection component so that, for example, a hinged flap, flexible bellows or self-levelling element results in a more precise removal of the layer of floating material.

2) Oleophilic Surface Skimmers:

The recovery mechanism consists of an oil-attracting material that is made to rotate so that the contaminant adheres to or is adsorbed on it. The entrapped contaminant is subsequently removed by scrapers or wringers and deposited in a reservoir. The collection component can be discs, vanes-and-discs, belt(s), rope mop(s), or drum(s) fabricated from polymers, metals and/or natural materials.

(3) Hydrodynamic Principles:

A variety of concepts are employed by some skimming devices to either redirect or submerge and concentrate a floating layer of material so that it flows into a central collection area from which it can be removed or transferred to storage. The different hydrodynamic principles utilized include a vortex chamber, rotating sorbent or non-sorbent belt, and rotating/submerging vane.

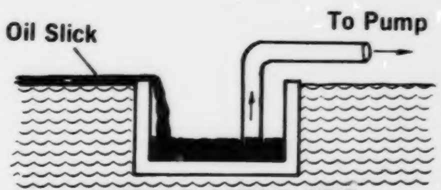
4) Boom/Skimmer Combinations:

Containment and removal operations are combined in a single system. Thus a boom incorporating collection weirs, or presenting a simple concentrating/deflection surface to incoming contaminant, directs the material to a pumping system through which it can be conveyed to storage.

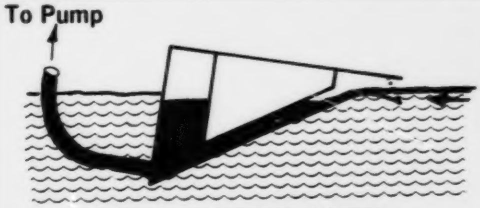
Note: Mechanical skimmers are usually used together with containment barriers (see Section 1.3) so that the material being collected is first concentrated. Also, vacuum trucks and air conveyors, although sometimes employed for the removal of floating substances, are examined separately in Section 2.3. See Large Suction Devices - General Listing. Smaller vacuum units are also included in Section 2.3 as a separate entry (see Small Suction Systems -General Listing).

PHYSICAL SPECIFICATIONS – Data for all categories of skimmers are contained in: Solsberg, L.B., A Catalogue of Oil Skimmers, Environment Canada, Ottawa, Ontario Report EPS 3-EP-83-1, (September, 1983).

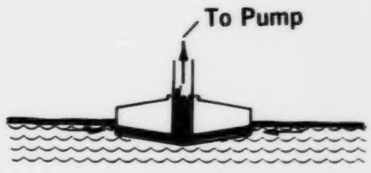
WEIR/SUCTION DEVICES



SIMPLE FLOATING WEIR

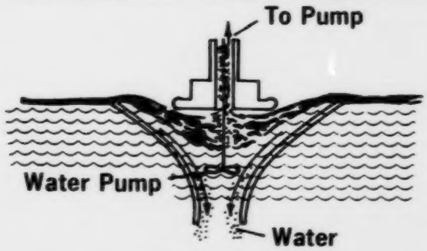


HYDRO-ADJUSTABLE WEIR

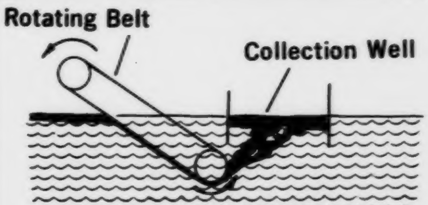


SIMPLE SAUCER WEIR

HYDRODYNAMIC DEVICES

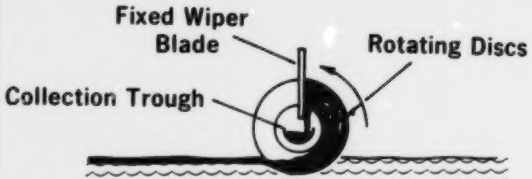


VORTEX WEIR

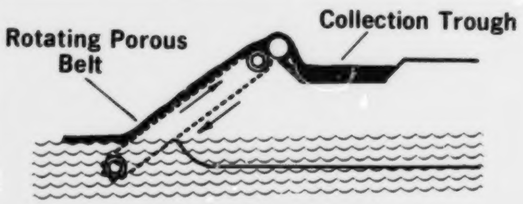


INVERTED ENDLESS BELT

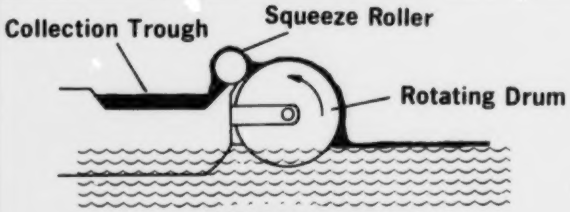
OLEOPHILIC SURFACE DEVICES



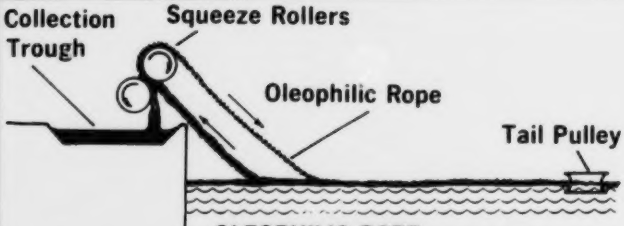
OLEOPHILIC DISK



OLEOPHILIC BELT

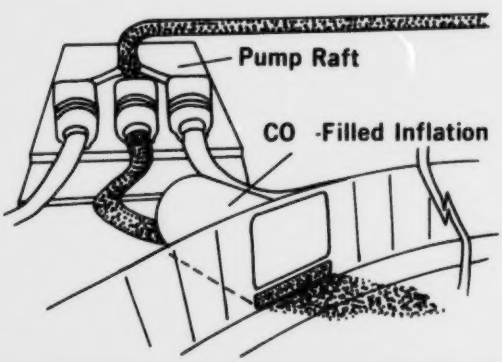


OLEOPHILIC DRUM



OLEOPHILIC ROPE

BOOM-SKIMMER COMBINATION



While the report deals with skimmers designed for the recovery of oil, these also may have application in some cases to hazardous materials spills. The Environment Canada manual describes skimming systems organized according to an alphabetical index of manufacturers/developers reproduced here. There is not a categorization of machines based on skimming principles. Note that names of companies that are capitalized in the index appear in the catalogue in a more detailed, comprehensive format as opposed to abbreviated entries which are listed in upper and lower case letters. The catalogue also contains a second reference index which presents the model designations and/or names of devices in alphabetical order but which has been excluded from this publication:

ACME PRODUCTS CO.
AERODYNE DEVELOPMENT CORP.
AGAR CORPORATION
Ajinomoto Co. Inc.
Alexander Cardew Limited
Allied Farm Equipment
Allweiler AG
Alsthom Atlantic Co.
ALSTHOM ATLANTIQUE
American Oil Co.
Annand Steel
ANTI-POLLUTION, INC.
Atlantic Research Marine Systems
B. Cellini
C. LUHRING SCHIFFSWERFT GmbH & CO. KG
CO. BA. DI.
Coleman Environmental & Pollution Control Equipment Co., Inc.
Containment Systems Corp.
Control and Metering
Core Laboratories
Cosmos Dredging v.o.f.
COSTRUZIONE BATELLI DISINQUINANTI S.p.A.
Crisafulli Pump Co., Inc.
De Smithske A/S
DOUGLAS ENGINEERING
Dynamics Corp. of America
Eimbcke Oilskimmer GmbH
ENTREPRISE SANITAIRE ET DE CANALISATION
ENVIRONMENT PROTECTION MACHINES LTD.
Esso Research Centre (UK)
Euro-Matic Ltd.
Far East Levingston Shipbuilding Ltd.
Bennex Marine Products and Services
Biggs Wall Fabricators Ltd.
BLACK SEA CENTRAL PLANNING AND DESIGNING BUREAU
BODAN-WERFT Motoren- und Schiffbau GmbH
Boss Industry
British Petroleum Company Limited
CANADIAN COAST GUARD
CENTRIFUGAL SYSTEMS, INC.
CENTRI-SPRAY CORPORATION
C. Hoyer
Clean Atlantic Associates
CLEAR SEAS ATLANTIC LTD.
Harmstorf Limited
Harrier Marine Limited
Houlder Offshore Ltd.
Hyde Products, Inc.
HYDROVAC SYSTEMS (HOLLAND) BV
I.H.C. Holland
INDUSTRIAL AND MUNICIPAL ENGINEERING
Industrial Plastics Canada Ltd.
INDUSTRIE MECCANICHE ING.A. SCARDELLATO
Intermar Corp. S.A.
JBF SCIENTIFIC CORPORATION
John Koblanski
Kaldnes Mekaniske Verksted A/S
Kepner Plastics Fabricators Inc.
Kristiansand Mechaniske Verskted
Krupp Handel GmbH
Krupp Reederei und Brennstoffhandel
Lindo Shipyard
Lisep Ltd.
LOCKHEED MISSILES & SPACE COMPANY INC.

FRISKEREDSKAP A/S
FRAMNAES MEK. VAERKSTED
Frank Ayles & Associates Ltd.
FRANK MOHN FUSA A/S
Frimokar Anstaly
GLOBAL OIL RECOVERY SYSTEMS, INC.
Gotaverken
Gotaverken-Finnboda
GUSTAF TERLING AB
Gustav Trellenberg K.G.
Haliburton Services
Harding Pollution Control
METROPOLITAN PETROLEUM PETROCHEMICALS CO., INC.
M.G. JOHNSON - DEVELOPER
Mitsubishi Heavy Industries Ltd.
Morishita Chemical Industry Co. Ltd.
MORRIS INDUSTRIES LTD.
Mount Royal Marine Repairs Ltd.
MSE Engineering Systems Ltd.
Nagasaki Shipyard & Engine Works
Napier Reid Ltd.
NEBB A/S
Netherlands State Waterways Board
Newfound Training Ltd.
Norwegian Institute for Continental Shelf Research
NOUVELLES APPLICATIONS TECHNOLOGIQUES
NYLANDS VERKSTED
OCEAN DESIGN ENGINEERING CORP.
Ocean Ecology Ltd.
Oceaneering International, Inc.
OCEAN SYSTEMS, INC.
OFFSHORE DEVICES, INC.
Oil Gulp
OIL MOP, INC.
OIL MOP POLLUTION CONTROL LTD.
OIL RECOVERY INTERNATIONAL
OIL RECOVERY SYSTEMS, INC.
OIL SKIMMERS INCORPORATED
Oil Sweeper Corporation of Canada Ltd.
O.M.I. Limited
Lowe Engineering Company
L.P.I. CORPORATION
MACMILLAN-BLOEDEL LTD.
MANNESMANN ITALIANA SPA
MARCO POLLUTION CONTROL
Marine Equipment Ltd.
Marine Pollution Control Corporation
MARTIN F. OLSEN - DEVELOPER
Martin Marietta Corporation
MATTSSON PRODUCKTER AB
McNamara Corporation Limited
MEGATOR CORP.
Peabody Welles Inc.
PEMBINA EQUIPMENT DESIGN CO. LTD.
PETRO-FIBER, OLJESANERING, AB
Philip C. Speer and Associates, Inc.
PRICE-DARNALL OF ALABAMA INC.
Promaco A/S
Ragnar Blesvik
Raumfahrttechnik GmbH
R.B.H. CYBERNETICS (1970) LTD.
R.E. Wright Associates, Inc.
REYNOLDS SUBMARINE SERVICES CORP.
Lt. Cdr. R.G. Teasdale
RHEINWERFT GmbH & CO.
Rijkswaterstaat
RNG Equipment Ltd.
Romsdals Fiskevegnfabrikk A/S
Rotork Marine Ltd.
SAMSEL ROPE & MARINE SUPPLY
SANDVIK CONVEYOR CANADA LTD.
SAPIENS
SCAN COMB LTD.
Scandinavia Maritime A/S
SCANDINAVIAN OIL SERVICE
S.C.D. PELICAN S.A.
SEA CLEAN O.R.E. LTD.
Sea Sweep, Inc.
Seaward International, Inc.
SEAWARD INTERNATIONAL INC.
SEP-EGMO
SHELL DEVELOPMENT COMPANY

PARKER SYSTEMS INC.
Parley Augustsson Shipping Group
Peabody Galion Corporation
Peabody Meyers Corporation
SLICKBAR, INC.
Slickbar
Spearin, Preston & Burrows, Inc.
Spiltrol
Star Offshore Services Ltd.
SUNSHINE CHEMICAL CORPORATION
SUPER PRODUCTS
SURFACE SEPARATOR SYSTEMS, INC.
Susquehanna Corporation
Tampa Drydock Company
Tetradyne Corporation
THUNE EUREKA A/S
TRACOR MARINE
Trygne Thune A/S
Tulagi Inc.
Shell Oil Company
Skim Inc.
Skimovex B.V.
Skuteng A/S
Ultrasystems, Incorporated
United States Coast Guard
UNOCO
VAC-U-MAX
VERSATECH PRODUCTS INCORPORATED
VIKOMA INTERNATIONAL, LTD.
Warren Spring Laboratory
WATERMASTER PUMPS & POLLUTION EQUIPMENT
Water Pollution Controls, Inc.
Welles Corporation
WELLES PRODUCTS CORPORATION
Worthington Corporation
W.R. BISHOP & ASSOCIATES
Wylie Oil Spill Recovery System

Skimmers are commercially available in a wide variety of sizes, designs and materials. They vary from small, portable units that can be easily carried to large, self-propelled vessels designed for offshore use. Most commonly, construction is of fiberglass, aluminum, steel or plastic with these materials or an oleophilic surface such as a polymeric made to contact the floating contaminant.

OPERATING SPECIFICATIONS – Skimmers are sold that are intended for use in ditches, ponds, lakes, rivers, harbours, coastal waters and offshore. Insofar as spills of hazardous materials are concerned, it is likely that light, portable systems have more potential application. These would be utilized in smaller water courses although their use may be limited if a boom cannot be initially deployed in time to deflect, contain and/or concentrate the released substance. Generally, optimum operation should be expected in quiescent, non-flowing water, at temperatures above freezing, and in free-flowing spilled materials concentrated to a thickness of 1 cm or more prior to collection. Except for direct immersion of a skimmer in a pool of highly concentrated chemical, it is probable that materials compatibility will not be a factor in the ultimate failure of the skimmer. Limited contact time and dilution of the spilled substance should reduce the likelihood of such damage. A case-by-case judgment, however, in this regard is recommended particularly concerning the skimmer's collection and transfer components. Attempts to skim in higher wind conditions i.e., 10.3 m/s (20 knots) and waves about 0.6 m (2 ft) - have a low potential of success.

STATUS OF DEVELOPMENT AND USAGE – Mechanical skimmers are commercially available and utilized world-wide particularly on oil spills. Documented use on hazardous materials is generally restricted to tank or laboratory testing of a limited number of devices in several substances rather than being based on actual spill experience.

PERFORMANCE – Summaries of optimum performance data for skimmers are presented in the following:

1) Solsberg, L.B., A Catalogue of Oil Skimmers, Environment Canada, Ottawa, Ontario Report EPS 3-EP-83-1 (September, 1983).

2) S.L. Ross Environmental Research Limited, The Efficiency of Mechanical Oil Skimmers, Environment Canada, Ottawa, Ontario (December, 1983) (unpublished).

Although both reports address oil skimming only, performance figures should be similar for many floating substances. The "Catalogue" briefly indicates optimum recovery rates and applications for specific skimmers while the "Efficiency" study more generally relates recovery effectiveness to sea state and viscosity. Performance trends from the second Environment Canada document are reproduced in this entry.

Because performance data even within one generic classification of skimmer vary widely, each device should be considered individually in order to precisely estimate recovery capability rather than predict this using the generalized curves.

Other overall trends include the following:

1) For weir devices, those that are self-levelling units and/or have high capacity pumps usually provide the highest capacity. Recovery rate should increase in increasing thickness of chemical in calm water but decrease abruptly in higher wind and wave conditions.

2) Oleophilic surface skimmers vary widely in performance potential. If appropriate to the chemical at hand, high recovery rates with little water can be achieved in low sea state conditions.

3) Machines operating on hydrodynamic principles and boom/skimmer combinations are not likely to have as much application to hazardous materials spills because of their large relative size, more complex deployment procedures and vessel requirements. The exception would be smaller, self-contained packages available as fast-launching units that could be quickly applied to spills.

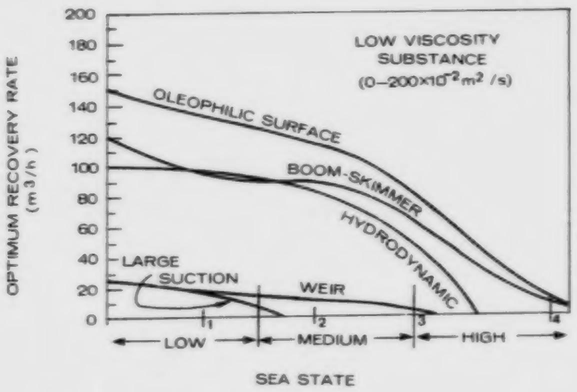
4) Expect best performance in contained, low and medium viscosity floating chemicals, in calm, quiescent water, using skimmers incorporating a collection mechanism and transfer system not affected by the released substance during the anticipated period of usage.

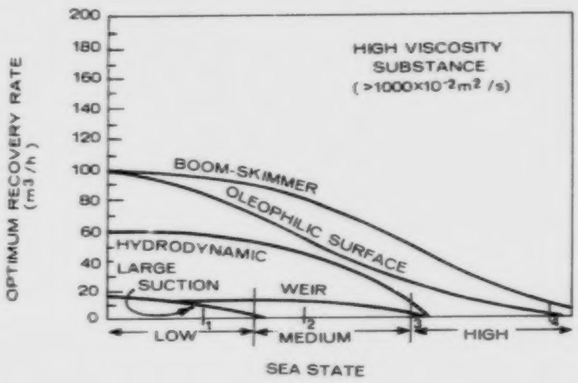
AVAILABILITY AND COMMERCIAL INFORMATION – Consult Environment Canada's "A Catalogue of Oil Skimmers". (See under Performance this entry.)

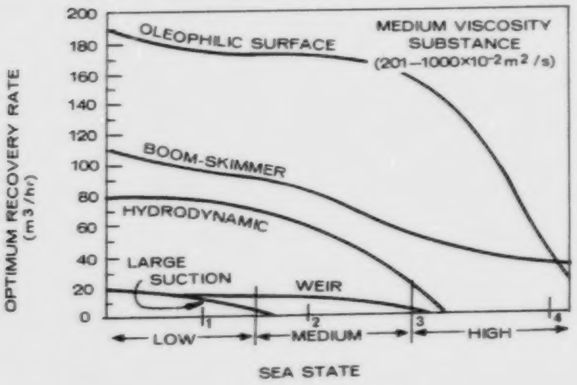
OTHER DATA – Refer also to:

Smith, G.F. and H.W. Lichte, "Summary of U.S. Environmental Protection Agency's OHMSETT Testing 1974-1979", U.S. Environmental Protection Agency, Cincinnati, OH, EPA-600/9-81-007 (January, 1981).

PERFORMANCE TRENDS - MECHANICAL SKIMMERS



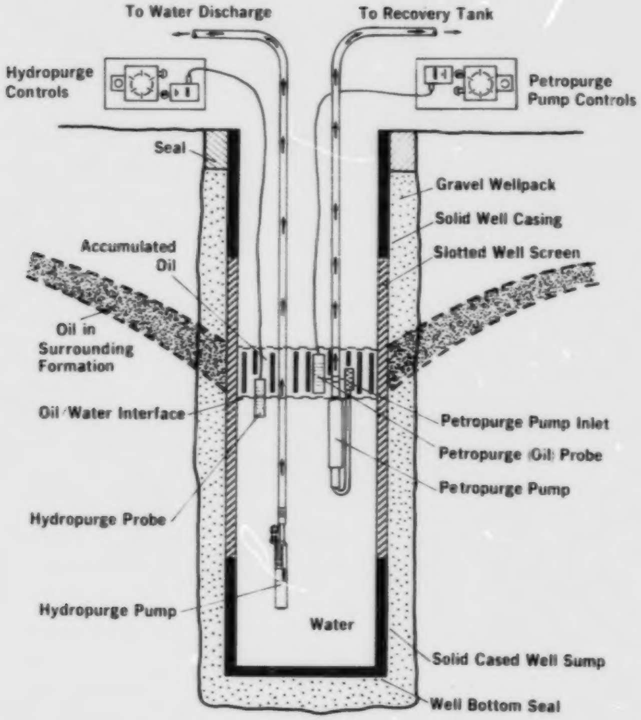




PRODUCT PETROPURGE GROUNDWATER DECONTAMINATION SYSTEM **No. 37**

APPLICABILITY	Gas	Liquid			Solid		
		Sol	Fl	Sk	Sol	Fl	Sk
			*				

DESCRIPTION – The Petropurge is a two-component system which automatically removes gasoline, fuel oil, and other liquid hydrocarbons from polluted soil and groundwater wells. It consists of two sets of pumps and sensing probes.



OPERATING PRINCIPLE – The Hydropurge Pump is water-specific and is controlled by a probe to keep the water surface below the static water table. This forms a "cone of depression" which causes the spilled substance to migrate through the surrounding soil and into the well. The Petropurge Pump inlet is positioned at the chemical-water interface, where the probe activates the pump when the chemical layer to be removed reaches a predetermined thickness.

PHYSICAL SPECIFICATIONS –

Petropurge Pump:

Pump -	Submersible centrifugal capable of transferring heads up to 30.5 m (100 ft).
Motor -	Explosion-proof, 230 volt, single-phase, 60 cycle, U.L. listed thermally protected. Available in 248, 560 and 1119 W (1/3, 3/4, and 1.5 hp).
Control Panel -	Supplied with explosion-proof plug and receptacle, lightning protector, and sensing probe.

Hydropurge Groundwater Drawndown Unit:

Pump -	Submersible centrifugal, stainless steel construction.
Control Panel -	Explosion-proof design with sensing probe. 115 V, single-phase, 60 cycle.

OPERATING SPECIFICATIONS –

Hydropurge Pump -	Standard 373 W (1/2 hp) capable of up to 106 L (28 U.S. gal) per minute at 15.2 m (50 ft). Larger capacities and discharge heads are available.

It is recommended that a trained geologist or hydrologist be contacted to properly locate and construct a recovery well.

STATUS OF DEVELOPMENT AND USAGE – Commercially available product conceived for groundwater contamination problems. Documentation of usage on hazardous materials spills was not obtained.

PERFORMANCE – Recovery of oil from wells at chemical tank farms has been reported by manufacturer.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:	Canadian Distributor:
Nepcco Equipment Division 7 Edgewater Place Norwalk, CT 06855 U.S.A. Telephone (203) 853-1990 or Sales Office: (617) 329-6898	Sanivan Inc. 1705 3e Avenue P.A.T. Montreal, Quebec H1B 5M9 Telephone (514) 353-9170 Telex: 05-829559 Contact: Mr. Pierre Richard

OTHER DATA – Nepcco can supply equipment meeting the requirements of situations where pump head and/or flow exceed the capability of standard equipment.

Reference: Manufacturer's Brochures: "The Petropurge System: How it Works" and "Petropurge Systems".

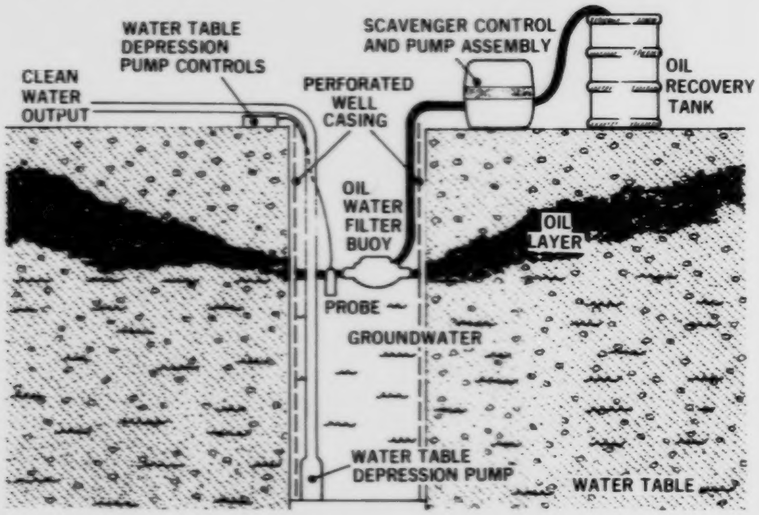
PRODUCT SCAVENGER PORTABLE SEPARATOR **No. 38**

APPLICABILITY	Gas	Liquid			Solid		
		Sol	Fl	Sk	Sol	Fl	Sk
			•				

DESCRIPTION – A system for separating and recovering floating hydrocarbons from water both above and below ground level. The components include a floating separator (Filter-Scavenger), a separator for confined spaces (Probe-Scavenger), and a submersible water pump (Water Table Depression Probe-Pump).

Water Table Depression

Oil/Water Separation



OPERATING PRINCIPLE –

Filter-Scavenger: The filter cartridge mounted in this floating collection unit rejects water but allows oil and certain hydrocarbons to pass to an inner collection area. The recovered product is automatically pumped to a recovery tank.

Probe-Scavenger: A probe differentiates between hydrocarbons and water, preventing the unit's submersible pump from pumping water into the recovered product tank.

Water Table Depression Probe-Pump: This submersible pump creates a "cone of depression" in a recovery well when removing clean groundwater. This depression causes hazardous materials to flow from the surrounding area toward the Filter-Scavenger or Probe-Scavenger (see Figure). A probe attachment shuts the pump off when hazardous materials approach the pump's intake.

PHYSICAL SPECIFICATIONS –

Filter-Scavenger:

Floating Separator/Collection Unit:

Diameter - 44.4 cm (17.5 in)
Height - 24.1 cm (9.5 in)
Draft - 12.7 cm (5 in)
Weight - 5 kg (11 lb)

Anodized aluminum; filter cartridges made of PVC or epoxy (optional metal and Viton or teflon seals for more corrosive solvents).

Hoses - 4.6 m (15 ft) input, 6.1 m (20 ft) output; 19 mm (3/4 in) diameter; gasoline-resistant.

Hose Fittings - "Kamloc" quick-disconnect.

Motor Control and Pump Assembly:

Motor - 1/4 hp explosion-proof, with
a) 115 Vac, 50/60 Hz, 4.2 A, 1460/1725 rpm, or
b) 200/230 Vac, 50/60 Hz, 2.1 A, 1460/1725 rpm, or
c) 12 VDC, 14 A, 1750 rpm

Dimensions - 45.7 x 45.7 x 17.8 cm in height (18 x 18 x 7 in)

Case: Fiberglass, weatherproof, designed to store all components of the system 61 x 61 x 61 cm (24 x 24 x 24 in)

Total Unit Weight: 50 kg (110 lb)

Probe-Scavenger:

Overall System - Hose - 32 m (105 ft)
Power Cord - 31 m (100 ft)
Total Weight - 68 kg (150 lb)

Probe - Diameter - < 51 mm (2 in)
Length: 305 mm (12 in)
Corrosion and gasoline resistant
Float and conductivity logic sensors
Splash and spark proof

Pump Control Assembly - Mounted on anodized aluminum board
Board: 406 x 356 mm (16 x 14 in)
2 m SO cable
NEMA 15 explosion proof plug
4-position selector switch - Hand-Off-Auto-Probe

Pump - Multistage, Celcon impellers and diffusers
Motor - 1/3 hp, 230 V, single-phase, permanent split capacitor
Thermal overload
Explosion-proof

Submersible

Water Table Depression Probe-Pump:

Pump - Prosser 3/4 hp 110 V, single-phase with 15 m (49 ft) of 50 mm (2 in) gasoline resistant hose.

Conductivity Probe - 50 mm (2 in) diameter, 300 mm (11.8 in) long, lowered by probe wire
24 V; AC to prevent electrolysis; current < 1 mA
Corrosion and gasoline-resistant, spark-proof.

Probe weight - 0.9 kg (2 lb)
Electronic control weight - 3.6 kg (8 lb)
Pump, hose, power cord weight - 28.5 kg (63 lb)

OPERATING SPECIFICATIONS — General CHEMICAL COMPATIBILITIES with the Filter-Scavenger and Probe-Scavenger:

Substances recovered by these systems should have the following properties:

- immiscible with water and non-polar solvents;
- specific gravity less than 1.0 and kinematic viscosity less than 45 m^2/s;
- a contact angle with membrane coating of less than 90°, and
- compatible with cartridge seals and the skimmer; a skimmer made of metal and seals of Viton or Teflon will be available for certain liquids.

The above criteria rule out salts, short-chain alcohols, carbon disulfide, chloroform, carbon tetrachloride and other dense solvents. The Viton/teflon system is necessary for aromatics and certain ethers.

The following chemicals are compatible with the normal Scavenger systems:

Alkanes: e.g., pentanes, hexanes, heptanes, etc.
Alkenes: e.g., 2-pentene, 3,4-dimethyl-2-hexene, etc.
Cyclic hydrocarbons: e.g., cyclohexane, methylcyclohexane, etc.
Alcohols with 4 or more carbons, e.g., n-butyl alcohol, hexanol, octanol, etc.
Esters with 5 or more carbons, e.g., pentyl acetate
Mixtures of the above: fuel oils, gasoline, kerosene, mineral spirits, naphthas, etc.
Mono-alkyl halides e.g., ethyl chloride, allyl chloride, etc.

The following chemicals are compatible with the metal Scavenger having Viton seals:
Aromatics: benzene, xylene, toluene, styrene monomer
Certain ethers and amines

The following chemicals are compatible with specially modified Probe Scavengers:
Ketones, short-chain amines, phenols, most polyhalogenated compounds.

In detail:

Filter-Scavenger:

Maximum recovery rate: 0.3 L/s (5 U.S. GPM).
Recovered product claimed to be virtually 100% water free.
Filters and recovers the waste until the surface slick "lenses".
Deployed in any area that is 61 cm (24 in) in diameter or larger.

Probe-Scavenger:

Pumping Rate:

Head m (ft)	Rate L/s (U.S. GPM)
4.6 (15)	2.4 (38)
9.1 (30)	2.1 (33.3)
13.7 (45)	2.0 (31.7)
18.3 (60)	1.5 (23.8)
21.3 (70)	1.0 (15.8)
24.4 (80)	0.5 (7.9)

Recovered product claimed to be virtually 100% water free.
Deployed in any area 20.3 cm (8 in) in diameter or larger; optional small diameter models available.
Operates at depths up to 26 m (85 ft).
Can be used with a battery as an interface detector.

Water Table Depression Probe-Pump:

Pump Rates:

Head m (ft)	Rate L/s (U.S. GPM)
0 (0)	5.4 (85)
3 (10)	4.8 (77)
6.1 (20)	3.5 (55)
9.1 (30)	1.6 (25)
11.3 (37)	shut off

Above rates for standard 3/4 hp pump. Larger horsepower pumps also available.

Deployed up to depths of 55 m (180 ft).
Probe can be preset to maintain the well level below the level of the surrounding water table.

STATUS OF DEVELOPMENT AND USAGE – Commercially available. In general use for spill response.

PERFORMANCE – Test data for application to hazardous materials are not available. Recovery rates of 0.4 to 0.5 L/min were recorded at 12°C in crude oil tests conducted on an earlier model of the Scavenger in October 1976 at Quebec City, Canada. Oil content was 100% in the collected liquid.

AVAILABILITY AND COMMERCIAL INFORMATION – Patents pending.

Manufacturer:

Oil Recovery Systems, Inc.
1420 Providence Highway
Suite 128
Norwood, MA 02062
U.S.A.
Telephone (617) 769-7600

Canadian Distributor

RNG Equipment
32 Stoffel Drive
Rexdale, Ontario
M9W 1A8
Telephone (416) 249-7383
Contact: Mr. Gord Duncan

OTHER DATA – The Filter-Bucket is a manual, passive system using the same filter cartridge technology as the Filter-Scavenger and has the same separation capabilities. It can be deployed in any area that is 25 cm (10 in) in diameter or larger. When its approximately 2 L capacity is full, a unit alarm indicates that it should be manually emptied.

Ground Technology, Inc. is a wholly-owned subsidiary of Oil Recovery Systems, Inc. offering hydrogeological services and cleanup options.

Groundwater Technology, Inc.
Rts. 1 & 100
Chadds Ford, PA 19317
U.S.A.
Telephone (215) 388-1466
Telex: 92-8420

References: Manufacturers' Literature; Abdelnour, R. et al., Field Evaluation of Eight Small Stationary Skimmers, Environment Canada, Ottawa, Ontario, EPS 4-EC-78-5 (May, 1978).

PRODUCT SMALL SUCTION SYSTEMS - GENERAL LISTING **No. 39**

See also the following separate entries this section:
Hako Minuteman Vacuum Systems
Harrier Hi-Vac Vacuum Units
NFE Hi-Vac Vacuum Cleaners/Conveyors
Nilfisk Mercury Vacuum Cleaner
Spillvac Vacuum Unit

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*	*	*	*

DESCRIPTION – Compact vacuum systems that are wheeled, portable or mobile designed for the recovery of liquid, solid or liquid/solid materials in plants, in other industrial applications, or, in some cases, at remote spill sites.

OPERATING PRINCIPLE – A vacuum is created in a chamber or small powerhead assembly by an engine and vacuum pump either integral to the collection vessel or located remotely from the suction head. An electric motor, air compressor, diesel engine or water pump is most commonly used to drive the pump. In some cases, a venturi effect based on air or water is used to establish suction. Filtration varies from the deposition of collected materials into lined or mesh containers to one, two and three stage systems which can include centrifugal separators, linear separators, and cloth dust collectors. Optional High Efficiency Particulate Air (HEPA) filters are often available with industrial-type vacuum cleaners which are designed to retain toxic dusts and other contaminants.

PHYSICAL SPECIFICATIONS – Refer to the above-noted separate entries for small suction units applicable to hazardous materials. For other vacuum devices having possible application to hazardous material spills, consult the manufacturers' literature for the following representative items (many other machines are sold locally, nationally and internationally):

1) BVC Portable Vacuum Cleaner

TEFV electric motor-driven industrial vacuum cleaners weighing 65 to 687 kg (143-1514 lb) in various capacities design for in-plant use.

2) Maniere Corporation

Self-propelled suction device intended for spill cleanup at industrial complexes; power source unspecified.

3) Nortech Corporation Compressed Air Powered Vacuums

Wet or dry industrial vacuum cleaners sold as 57, 114 and 208 L (15, 30 and 55 U.S. gal) complete units or vacuum head assemblies for drum-mounting; based on compressed air supplied in-plant.

4) Vac-U-Max Cleaning Equipment

Air compressor-driven portable vacuum head designed for both plant and remote spill locations (particularly oil slick cleanup); fits 205 L (45 gal) open-top drum.

5) Vikoma Nor-Vac Portable Vacuum Beach/Rock Cleaner

This 160 kg (352 lb) diesel/vacuum pumping system is marketed specifically for the cleanup of oil spills at remote sites. It features a power pack, vacuum chamber, suction wand, and water jet spray system.

6) Vikoma Vikovac

A self-contained diesel engine/vacuum pump/power head assembly weighing 350 kg (770 lb) is housed on a three-wheel trolley. The Vikovac is designed primarily as an oil spill cleanup device for suctioning spilled materials from beaches and other surfaces into drums.

7) Slickbar Trans-Vac

This is a diesel-driven, skid-mounted vacuum unit intended mainly for oil spill cleanup with the company's Manta Ray skimming heads which operate on the water's surface.

OPERATING SPECIFICATIONS – Refer to separate entries this section and manufacturer's literature. Note that vacuum and pressure are given in a wide variety of units. Typically, however, these suction devices create a vacuum of 100 to 500 mm (4 to 20 in) mercury (1360 to 6800 mm (53.5 to 268 in) H_2O) using air at 414 and 690 kPa (60 to 100 psi). A maximum (absolute) vacuum approaching 100 kPa (760 mm Hg) H_2O) would be theoretically possible. Capacity varies widely and is usually expressed in L/h liquids, t/h solids, L or receiving capacity, etc. It would be important to determine the availability of explosion-proof components and non-corrosive parts if these are needed for particular applications. The majority of the devices marketed are electric-powered vacuum cleaners designed for the cleanup of small spills in industrial plants. Other units have been conceived specifically for oil spill control or for routine maintenance tasks. Usage of these devices on spills of hazardous materials would require further study on an individual basis.

STATUS OF DEVELOPMENT AND USAGE – Commercial products universally available. Usage is generally not documented for the control of spills of hazardous substances remote from industrial plants.

PERFORMANCE – Evaluation data were not obtained for the application of small suction devices to the cleanup of hazardous materials.

AVAILABILITY AND COMMERCIAL INFORMATION – Contact information is presented for all devices discussed including those included as separate entries in this section.

BVC Portable Vacuum Cleaner

BVC Limited
Leatherhead, Surrey
England
Telephone Ashtead 76121
Telex 28134

Frank Ayles Spillvac

Frank Ayles & Associates Ltd.
120 Whitechapel High Street
London, England
EP1 7PT
Telephone 01-247-1926
Telex 886089 ab DENBRO

Hako Minuteman Vacuum Systems

American Cleaning Equipment Corporation
111 South Route 53
Addison, IL 60101
U.S.A.
Telephone (312) 627-6900

Sinclair MacDonald Products
112 Doncaster Avenue
Thornhill, Ontario
Canada L3T 1L3
Telephone (416) 889-8511

Harrier Hi Vac

The Materials Handling Division
Harrier Marine Limited
Pilsworth Road
Burry
Lancashire, England BL9 8RL
Telephone 061-796-8703
Telex 666754 ab HARPEX G

Manierre Industrial Vacuum Cleaner	Manierre Corporation Waukesha, WI U.S.A. (availability uncertain)
NFE Hi-Vac Vacuum Cleaners and Conveyors	NFE International Ltd. 300 Beeline Drive Bensenville, IL 60106 U.S.A. Telephone (312) 350-1110
	NFE Canada Limited P.O. Box 1277 Station B Burlington, Ontario Canada L7P 3S9 Telephone (416) 634-2342 Telex 0618219 ab NFE CANADA BUR
Nilfisk GS Series Commercial Vacuum Cleaners	Nilfisk of America Inc. 224 Great Valley Parkway Malvern, PA 19355 U.S.A. Telephone (215) 647-6420
	Nilfisk Ltd. 200 Connie Crescent, Unit 7 Concord, Ontario Canada L4K 1M1 Telephone (416) 669-6003
Nortech Compressed Air Powered Vacuums	Nortech Corporation 189 Greenwood Avenue Midland Park, NJ U.S.A. Telephone (201) 445-6900
Vac-U-Max Cleaning Equipment	Vac-U-Max 37 Rutgers Street Belleville, NJ 07109 U.S.A. Telephone (201) 482-1000
Vikoma Nor-Vac Vikoma Vicovac Beach Cleaners	Vikoma International Limited 88 Place Road Cowes, Isle of Wight P031 7AE England Telephone (0983) 296021 Telex 869111 ab VIKINT G

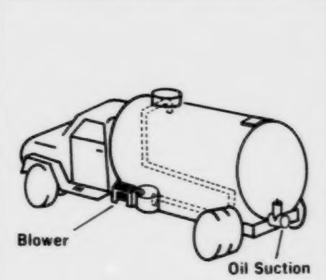
OTHER DATA — No other information obtained on small suction systems.

PRODUCT LARGE SUCTION DEVICES - GENERAL LISTING **No. 40**

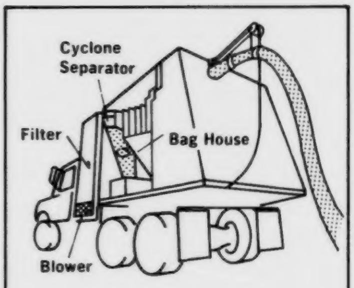
APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*	*	*	*

DESCRIPTION – Truck-, skid- or trailer-mounted vacuum systems with integral storage capability designed for the recovery of liquid, solid or liquid/solid materials in a variety of industrial applications as well as at remote spill locations.



VACUUM TRUCK



AIR CONVEYOR

OPERATING PRINCIPLE –

Vacuum Truck A low-volume vacuum pump or blower directly evacuates a large collection vessel or tank. The end of a suction hose leading to the tank is then placed in the material to be recovered. Skimming heads can be attached to the end of the hose to increase pickup efficiency in water; otherwise, the simple hose opening is used.

Air Conveyor A high flow rate of air is utilized to convey material into a collection tank through a large diameter hose. The end of the suction hose is held above the material to be recovered so that an adequate air flow is maintained. The high capacity blower is protected from liquids and particulates - including dust - by prefilter systems sometimes comprised of steel baffles as well as primary filtration such as venturi nozzles or other cyclonic separation process, and/or baghouse or multi-stage cloth filters.

PHYSICAL SPECIFICATIONS – Typical dimensions are:

	Vacuum Truck	Air Conveyor
Suction Hose Diameter (cm)	7.6 to 10.2	10.2 to 20.3
Length - excluding truck (m)	3 to 10	4 to 5
Tank Diameter (m)	1 to 2	1 to 3
Weight - excluding truck (kg)	2 000 to 8 000	5 000 to 8 000
Capacity (m^3)	2 to 23	5 to 15
Materials of Construction	0.64 to 0.79 cm (0.25 to 0.31 in) steel tank, stainless steel optional; also liners or coatings of asphalt, rubber, neoprene, epoxy and fibreglass sometimes available for corrosives.	

OPERATING SPECIFICATIONS – Typical values are:

	Vacuum Truck	Air Conveyor
Rated Vacuum (mm H_2O)	to 10 000	5 000 to 5 500
Air Flow (m^3/h)	200 to 5 000	6 000 to 10 000
Rotor Speed (rpm)	800 to 1 000	1 500 to 2 000
Pump Type	Vane	Positive displacement
Other	Hydraulically-operated tank-end door often featured.	

STATUS OF DEVELOPMENT AND USAGE – Commercially available products universally available. Both vacuum trucks and air conveyors have been used world-wide for the recovery of spilled materials including oil and hazardous substances. Advantages include gaining access to confined areas and minimizing potential contact with cleanup crews.

PERFORMANCE – Evaluation of large vacuum systems has been limited. Testing has been conducted, however, of a vacuum truck and an air conveyor using oil on water at the U.S. Environmental Protection Agency's Oil and Hazardous Materials Simulated Environmental Test Tank (OHMSETT) at Leonardo, NJ. For the air conveyor, a maximum recovery rate of 7.8 m^3/h was achieved in a slick thickness of 25 mm (1 in). Oil content in the collected liquid peaked at 72%. The vacuum truck, in one series of tests, was determined to be capable of recovering a maximum of 3.9 m^3/h of a 25 mm (1 in) thick slick and, in one run, oil content reached 40% but was otherwise much lower. In a second series of trials, the vacuum truck collected in excess of 10 m^3/h in a slick of 46 mm (1 3/4 in) and over 24 m^3/h when a skimming head was connected to the end of the hose. Factors which affected performance can be translated into the following conclusions and recommendations:

Spills on Water

Air conveyors are especially recommended for recovering thin layers or highly viscous products on water.

Vacuum trucks are better suited to the recovery of thick slicks than thin layers of floating materials.

Blower speed affects the efficiency with which these systems pick up materials; blower speed must also be selected consistent with proper truck engine maintenance.

Hose length may also affect performance.

Skimming heads should enhance the capability of vacuum trucks to recover floating materials.

Air conveyors should generally exhibit a greater tolerance of a variety of forms of debris.

Spills on Land

In the case of spills on land, large suction systems can be effectively utilized to remove materials from ditches or other hard-to-reach areas. Once the spilled substance is picked up, it remains confined until its ultimate disposal. If no water body is involved, a highly efficient recovery operation should be possible unless other interferences are encountered. These could include a quickly evaporating substance, fire hazard, highly viscous fluid, or physical obstructions which prevent use of the suction hose.

AVAILABILITY AND COMMERCIAL INFORMATION – Representative companies only are listed. Industrial registers and local telephone directories should also be consulted for manufacturers of vacuum equipment.

Aquatech-Moro
10620 Cedar Avenue
Cleveland, OH 44106
U.S.A.
Telephone (216) 231-1010

Jet-Vac System

Airesearch, Inc.
4007 Seventh Court, North
Birmingham, AL 35222
U.S.A.
Telephone (205) 591-2477

Guzzler Air Vacuum Loader

Central Engineering Co., Inc.
4427 West State Street
Milkwaukee, WI 53208
U.S.A.
Telephone (414) 933-4567
Telex 26641

Vac-All

VCR Series

DP Way Corporation P.O. Box 09336 Milwaukee, WI 53209 U.S.A. Telephone (800) 558-6944	Ultravac
Industrial and Municipal Engineering P.O. Box N U.S. Route 34 East Galva, IL 61434 U.S.A. Telephone (309) 932-2036 Telex 510-390-8006	Vacuum Inductors
Kleener Kleener Incorporated 6248 Honeytown Road Smithville, OH 44677 U.S.A. Telephone (800) 321-4932	Power-Vac
NFE International Ltd. 300 Beeline Drive Bensenville, IL 60106 U.S.A. Telephone (312) 350-1110	Hi-Vac Vacuum Loaders
In Canada contact: NFE Canada Limited P.O. Box 1277 Station B Burlington, Ontario L7P 3S9 Telephone (416) 634-2342 Telex 061 8219 ad NFE CANADA BUR	
Peabody Myers 1617 South Illinois Street Streator, IL 61364 U.S.A. Telephone (815) 672-3171	Vactor
Power-Vac, Inc. Dept. M P.O. Box 20905 Milwaukee, WI 53220 U.S.A. Telephone (414) 933-8989	Industrial Vacuum Loaders
Sanivan Inc. 1705 3rd Avenue Pointe-aux-Trembles, Quebec Canada H1B 5M9 Telephone (514) 353-9170 Telex 05-829559	Industrial Vacuum Loaders
Super Products P.O. Box 27225 Dept. T Milwaukee, WI 53227 U.S.A. Telephone (800) 558-6190 or (414) 787-7100 Telex 26-9566 a/b SUPROCORP NBLN	Supersucker

In Canada contact: Wajax Industries Ltd.
6555 Cote de Liesse
Montreal, Quebec
H4T 1E6
Telephone (514) 342-9570

Transway Systems, Inc. — Vacuum Systems
330 Leaside Avenue
Stoney Creek, Ontario — (formerly J.B. Systems Limited)
Canada
L8E 2N7
Telephone (416) 662-5435
Telex 061-8661

Wm. W. Meyer & Sons, Inc. — Meyer Klean King
8262 Elmwood Avenue — Powervac Cleaners
Skokie, IL 60077
U.S.A.
Telephone (312) 673-0312

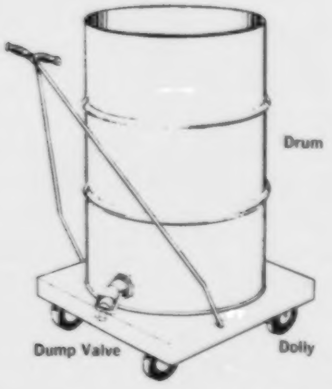
OTHER DATA – Because of the high capital cost of large suction systems, cleanup contractors who own and operate such equipment are usually called upon in the event of hazardous material spills. A separate listing of contractors is contained as an Appendix of this report.

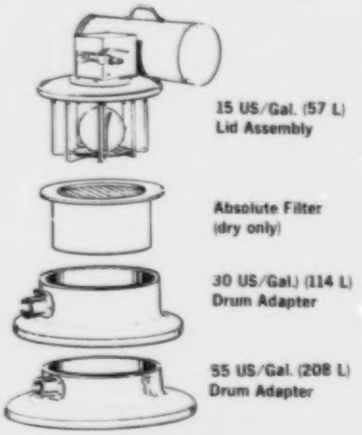
Reference: Gates, D.C., K.M. Corradino, and W.R. Senfter, "OHMSETT Tests of Truck-Mounted Vacuum Systems for Oil Spill Recovery", Proceedings of the 1983 U.S. Oil Spill Conference, San Antonio, TX (Feb - Mar, 1983.

PRODUCT HAKO MINUTEMAN VACUUM SYSTEMS **No. 41**

APPLICABILITY	Gas	Liquid			Solid		
		Sol	Fl	Sk	Sol	Fl	Sk
		*	*	*	*	*	*

DESCRIPTION – Small industrial vacuum cleaners designed for the in-plant and laboratory pickup of hazardous wastes in wet or dry form including nuclear, mercury, chemical, asbestos and other materials.





OPERATING PRINCIPLE – A vacuum is created in the collection tank either by an electric motor integral to the unit or by a remote source of compressed air. When used for dry pickup, four filters including HEPA, impact, cloth bag and protector bag entrap contaminants and treat all air flowing through the system.

PHYSICAL SPECIFICATIONS – (800 series only)

Model	X-100	X-1700	X-703	X-1000	MX-1000	MRS*
Overall Height (cm)	88 & 122	48 & 61	84 to 130	64 to 135	236	104 & 117
Width (cm)	53 & 61	36	53 & 64	36 to 64	53	53
Weight (kg)	40 & 58	10 & 11	23 to 51	10 to 55	39 & 38	28 to 35
Dry Capacity (m^3)	0.05 & 0.12	0.006 & 0.04	0.02 to 0.2	0.006 to 0.2	0.06	0.02 & 0.06
Power (W)	1 180	air	air	930 & 1 180	1 180	1 480

*MRS = mercury recovery vacuum system

OPERATING SPECIFICATIONS – (800 series only)

Model	X-100	X-1700	X-703	X-1000	MX-1000	MRS
Static Lift (mm H_2O)	2235	5537	5537	2235	2235	2794
Air Flow (m^3/min)	3.6	4.7	4.7	2.7 & 3.6	3.6	3.3
Air Pressure (kPa)	—	621	621	—	—	—
Compressed Air Flow (m^3/min STP)	—	1.19	1.19	—	—	—

Drum adapters are available to enable the use of 57 L (15 U.S. gal) lids on 114 and 208 L (30 and 55 U.S. gal) drums.

All models include impact-type filter with 90 to 95% efficiency (DOP standard test).

All models also can utilize and HEPA filter 99.7% effective at 3 μm.

Hako vacuum cleaners are U.S. Government (OSHA) approved for use in hospitals, "white rooms", electronic assembly areas, testing labs and nuclear plants.

Mercury recovery vacuum systems (MRS) feature a critical filter suitable for the pickup of liquid mercury and mercury-contaminated dry and liquid soil and air.

Asbestos vacuum has efficiency rating of 99.999% on particles of 5 μm; it uses a five-stage filter.

All models have wheels except the X-1700 and two smaller X-1000 units.

STATUS OF DEVELOPMENT AND USAGE – Commercial products specifically designed to recover hazardous materials in plants. Documentation relating to spills not received.

PERFORMANCE – No evaluation data obtained.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

American Cleaning Equipment Corporation
111 South Route 53
Addison, Il 60101
U.S.A.
Telephone (312) 627-6900
Contact: Mr. Charles Kallil

Canadian Distributor:

Sinclair MacDonald Products Ltd.
112 Doncaster Avenue
Thornhill, Ontario
Canada
L3T 1L3
Telephone (416) 889-8511
Telex 06-964731
Contact: Mr. Gerry Wilson

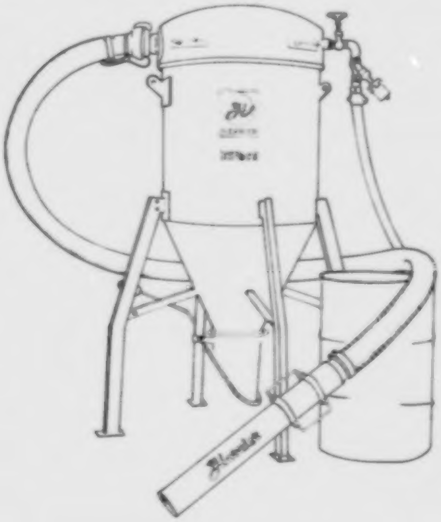
OTHER DATA – None obtained.

PRODUCT HARRIER HI-VAC VACUUM UNITS **No. 42**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	•	•	•	•	•	•

DESCRIPTION – A portable air-powered venturi system designed for the recovery of liquids, solids and slurries in plants and at remote spill sites.



OPERATING PRINCIPLE – An air compressor is used to create a vacuum via a venturi system. Material enters through a suction line, remains separated from the venturi, and is directed through a hopper into a storage container. An on/off switch mounted on the inlet hose, and various configurations of end fittings, facilitate initial material pickup.

PHYSICAL SPECIFICATIONS – five models are available:

Model	HV 2	HV 4	HV 6	HV 9
Weight (kg)	26	37	58	81
Diameter (mm)	609.5	609.5	762	914.5
Height (mm)	444.5	444.5	444.5	508

Air Hose - Length (m)	30 (all models)
- Type	Nylon-reinforced rubber (all models)
Pickup Hose - Length (m)	9.1 (all models)
- Type	Green Kanoflex (all models)
Other	All models fit individually-sized hoppers. HV 2 and 4 power head also fit onto standard open-top drum.

The fifth model, called the Sco Vac Unit, is self-contained and trailer-mounted and is comprised of:

- HV 4 power head;
- hopper and hopper support frame;
- 3412 L storage bag;
- air hose, pick up hose, fittings, snorkel recovery pipe; and
- Atlas Copco Silensair compressor rated at 158 L/s.

OPERATING SPECIFICATIONS –

Model	HV 2	HV 4	HV 6	HV 9
Vacuum (552 - 690 kPa)	457 (all models)			
Recommended Air Pressure - kPa (bar)	507 to 709 (5 to 7) all models			
Consumption (L/s)	68	136	204	306
Output (L/h)	25 025	40 590	56 875	86 450

STATUS OF DEVELOPMENT AND USAGE – Commercial products developed for the recovery of oil and a wide range of dry and liquid hazardous materials. Documented application to spills was not obtained.

PERFORMANCE – No evaluation data reviewed.

AVAILABILITY AND COMMERCIAL INFORMATION –

Materials Handling Division
Harrier Marine Limited
Pilsworth Road, Bury BL9 8RL
Lancashire, England
Telephone 061-796-8703
Telex 666754 a/b HARPEX G

OTHER DATA – Temporary storage bags are available up to 22 730 L (5000 gal) capacity.

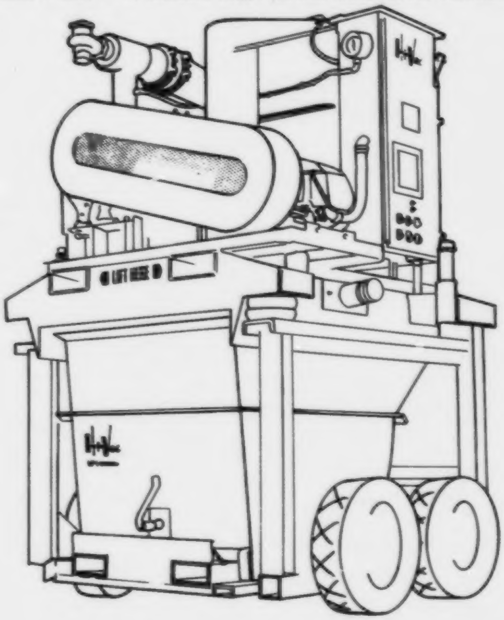
The High-Vac series is designed for the removal of materials from both land and the surface of water bodies.

PRODUCT NFE HI-VAC VACUUM CLEANERS/CONVEYORS **No. 43**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*	*	*	*

DESCRIPTION – A mobile high-power industrial vacuum for liquid, solid or liquid/solid material pick-up.



OPERATING PRINCIPLE – A "powerhead" containing the vacuum pump draws materials through a 50 mm (2 in) line, then through a three-stage filtration system which removes the material from the air stream.

PHYSICAL SPECIFICATIONS – Several models available, all of which may be mounted on rubber tire trailers for portability. Self-propelled and permanent installation versions are also available. Dimensions (not including hoppers):

Model	Length (mm)	Width (mm)	Height (mm)
310	1143	1118	1956
220, 240LC	1727	2134	1219
225, 230, 240, 250, 275	1727	1880	1727
2075, 2100, 2150	3505	3023	1981

Weights Output:

Model	Weight (kg)	Power (hp)
310	910	10.1
220	1360	20.3
225	1590	25.4
230	1860	30.4
240	2040	40.6
250	2260	50.7
275	2495	76.1
2100	3630	101.4
2150	4310	152.1
2300	6805	304.2

OPERATING SPECIFICATIONS – Pickup capacities up to 140 t/h (at 15 m (49 ft) conveying distance) depending on model selected and density of material. May be used to pickup the following materials:

Light weight (up to 800 kg/m^3) Aluminum chips, ashes, bakelite, carbon black, charcoal, iron oxide, plastic pellets, sawdust, titanium dioxide, vermiculite and zinc oxide.

Medium weight (810 to 1750 kg/m^3) Bentonite, borax, cement, coal, copper sulphate, kaolin, lime, limestone, phosphate, quartz, rubber, salt, sand and shale.

Heavy weight (>1750 kg/m^3) cast iron chips, clay, glass cullets, iron ore, lead ores, lead oxide, maganese ore, potassium chloride (pellet), pyrite (pellet), slag, steel chips, taconite pellets, zircon sand.

Maximum conveying distances:

Model	Heavy	Medium	Light
310	15	23	31
220	15	31	38
225	27	42	65
230	38	61	91
240	53	84	122
250	69	107	152
275	91	137	198
2100	114	175	252
2150	145	221	312
2300	229	335	457

Model	Power (hp)	Hopper Capacity (m^3)	Motor Type	Closed Suction (cm H_2O)	Max (m^3/min)
Pussycat	1	0.017	electric	211	2.7
Lynx	1	0.034	electric	211	2.7
Tiger	2	0.048	electric	211	5.4
Panther	3	0.048	electric, LP gasoline air	234	4.6
Puma	5	0.057	electric	272	5.1

Note also for all models reviewed:

- electric motors are standard
- optional diesel, LP, gas engines except as specified
- explosion-proof controls available
- HEPA filtration system for hazardous materials
- epoxy coating for corrosives

STATUS OF DEVELOPMENT AND USAGE – Commercial products. Documentation of application to spills of hazardous materials not obtained.

PERFORMANCE – No evaluation data obtained.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:
NFE International Limited
300 Beeline Drive
Bensenville, IL 60106
U.S.A.
Telephone (312) 350-1110

Distributor:
NFE Canada Limited
P.O. Box 1277
Station B
Burlington, Ontario
Canada L7P 3S9
Telephone (416) 634-2342
Contact: Mr. J.H. Robb, Operations Manager

OTHER DATA – NFE International also distributes the Hi-Vac Cat Series manufactured and sold under license from Sturtevant Engineering Co. Ltd. of Europe. These are portable, wet/dry vacuum systems designed for industrial applications. Five models are available all with optional toxic dust filters (HEPA):

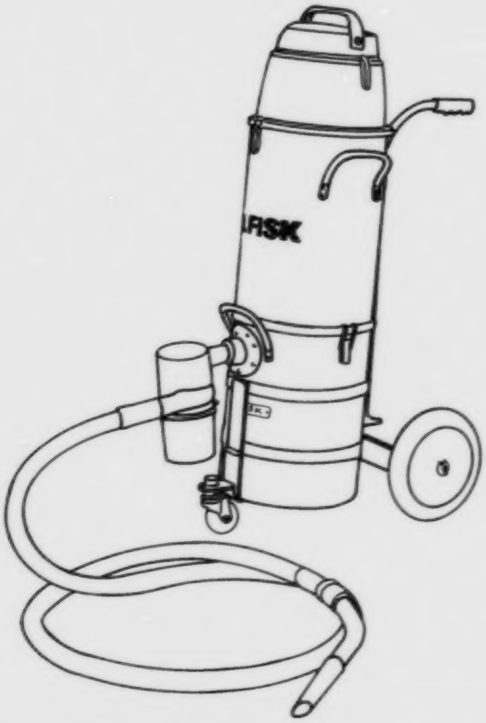
Reference: Manufacturers' Literature.

PRODUCT NILFISK MERCURY VACUUM CLEANER **No. 44**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
			*			

DESCRIPTION – A portable mercury recovery system for the cleanup of mercury spills in laboratories, manufacturing facilities and on land. It consists essentially of a vacuum cleaner unit, a separator, a carbon cartridge filter and hose.



OPERATING PRINCIPLE – Suction from the vacuum unit draws the mercury through a hose and into a centrifugal droplet separator where liquid mercury is collected. Any dust or debris from the operation is collected in a disposable bag inside the unit. The air is then passed through an activated carbon adsorbent filter eliminating mercury vapours from the vacuum exhaust. Finally, the air passes through a microfilter and is released to atmosphere.

PHYSICAL SPECIFICATIONS –

Motor - 115 V, 60 cycles
Power consumption - 700 W
Height - 1143 mm (45 in)
Length - 762 mm (30 in) (with trolley)
Width - 495 mm (19.5 in) (with trolley)
Weight - 39 kg (86 lb) without accessories
Suction Inlet - 32 mm (1.3 in)
Container - 20 L (5 U.S. gal) stainless steel
Droplet bottle - 1 L (0.3 U.S. gal) (unbreakable plastic)
Hose - Neoprene-lining, 3 m (10 ft) long, 32 mm (1.3 in) I.D.
13.6 kg (30 lb) charge of activated carbon
Optional high efficiency particulate air filter

OPERATING SPECIFICATIONS –

Vacuum - 18.6 kPa (maximum waterlift)
Air flow - 0.04 m^3/s at container inlet
Can collect both liquid mercury and mercury compounds.

Can collect liquid mercury for future reuse or disposal (separator).
Meets or exceeds OSHA standards for inorganic mercury.
Easily replaceable particulate and vapour filters.
Microfilter yields 99.5% efficiency at 2 µm.

STATUS OF DEVELOPMENT AND USAGE – Commercial product. Usage on hazardous material spills not documented.

PERFORMANCE – No evaluation data obtained.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Nilfisk of America, Inc.
201 King Manor Drive
King of Prussia, PA 19406
U.S.A.
Telephone (215) 277-3900

OTHER DATA – Other vacuum systems are available in a wide range of models to collect or filter toxic materials such as lead, asbestos, silica, berylium alloy, insecticides, cotton dust and other dusts.

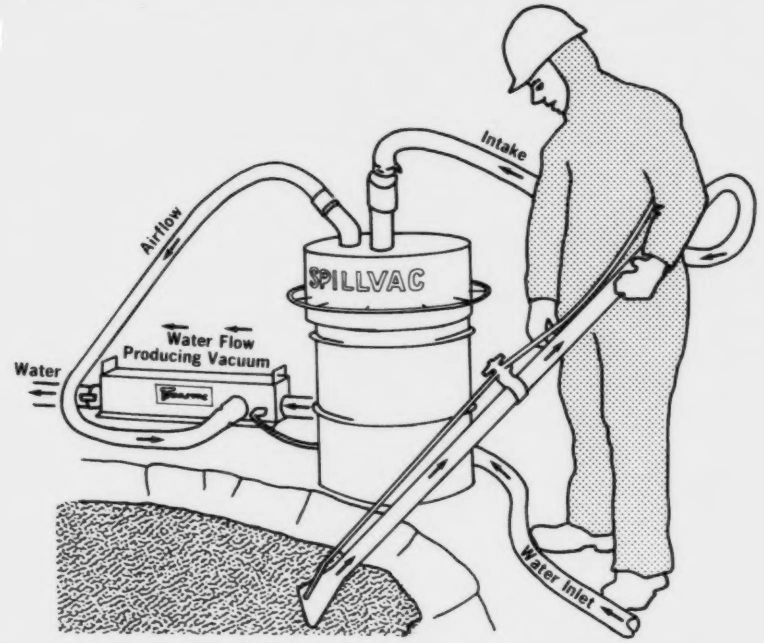
Reference: Manufacturers' Literature.

PRODUCT SPILLVAC VACUUM UNIT **No. 45**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*	*	*	*

DESCRIPTION – A portable water-powered venturi conceived for the recovery of liquids, solids and slurries at plants, refineries and remote spill sites.



OPERATING PRINCIPLE – A water pump is used to drive a venturi thus creating a vacuum in a power head assembly. The power head can be directly applied to a standard 205 L (45 gal) drum or mounted on a hopper over any bulk storage vessel for interim deposition of the collected material.

PHYSICAL SPECIFICATIONS –

Gross Weight - 120 kg (264.5 lb)
Shipping Container - Size - 1200 x 800 x 500 mm (47 x 31.5 x 20 in)
- Type - metal alloy
Vacuum Head - stainless steel, size unspecified

Suction Hose - Length - 10 m (33 ft)
Vacuum Hose - Length - 10 m (33 ft)
Water Jet Hose - Length - 25 m (82 ft)
Water Inlet Connections - 6.4 cm (2 1/2 in) male/female "instantaneous"
Vacuum Inlet Connection - 7.6 cm (3 in) Quick Coupler
Water Jet Supply Connection - 1.3 cm (1/2 in) Quick Coupler
Construction Materials - vinyl ester resins, polyvinylidene fluoride (PVDF) and chlorosulphonated polyethylene (Hypalon) in SVH model designed for corrosives.

OPERATING SPECIFICATIONS –

Air Flow at Pickup Mechanism - 4 to 6 m/s
Pressure at Pickup Mechanism - 500 mm (20 in) Hg maximum
Water Requirement - 225 L/min @ 6 to 8 bar
Collection Rate (Liquid) - 200 L/min
Maximum Lift - 4 to 5 m (13 to 16 ft)

STATUS OF DEVELOPMENT AND USAGE – Commercial product designed for spill cleanup. Documented usage on hazardous material spills not reported.

PERFORMANCE – No evaluation data obtained.

AVAILABILITY AND COMMERCIAL INFORMATION –

Frank Ayles & Associates Ltd.
120 Whitechapel High Street
London EP1 7PT
England
Telephone 01-247-1926
Telex 886089 ab DENBRO

OTHER DATA – The water used to drive the venturi does not contact the material to be recovered and so can either be reused or released without treatment.

Two spillvac devices are available: the SVO model is intended for the collection of oil and non-corrosive materials while the SVH unit is constructed to process corrosives.

Options include hopper and stand, flexible PVC holding tank, PVC pillow tank, dust bags, drum trolley, and Transvac eductor.

2.4 Sorbents

PRODUCT SPILL SORBENTS - GENERAL LISTING **No. 46**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – Natural and synthetic materials, or combinations thereof, that can be used to absorb and/or adsorb spilled liquid materials on land or, in some cases, on water.

OPERATING PRINCIPLE – The sorbent is broadcast in loose form (usually in the event of a spill on land) or applied as a pillow, pad, rug, boom or in other format on land or on water to pick up materials released in minor amounts during accidental discharges. The sorption process is a physical one which can, if the situation warrants it, be repeated with some sorbent pads and foams if these are wrung out between individual applications at the spill site.

PHYSICAL SPECIFICATIONS – Sorbents vary in format from small particles several millimetres in size to mats, pads and rolls generally 50 to 100 cm (20 to 40 in) in width by 0.5 to 1 cm (0.20 to 0.40 in) in thickness. Materials commonly used in the fabrication of sorbents include:

1) Natural Organics – of animal or vegetable origin and encompass peat moss, straw, sawdust, corn cobs, bark, etc.

2) Natural Inorganics – fabricated from various minerals; clays, vermiculite, perlite, diatomaceous earth and fly ash are examples.

3) Synthetic or Modified Sorbents – Often polymeric materials, such as polyurethane foam, polyethylene, and polypropylene. Other types include modified organics such as treated cellulose backed by a polymeric netting, modified inorganics such as expanded vermiculite or treated perlite, and various synthetic chemical and rubber products.

The manufacturers' literature should be consulted for available sizes, formats and material composition.

OPERATING SPECIFICATIONS – Most sorbents can be applied over a wide range of ambient temperatures, providing the material to be picked up is in liquid form. In the case of some products such as peat moss, which can retain moisture, usage in sub-freezing temperatures may not always be possible. Warehouse storage of sorbents is usually required to prevent or minimize their deterioration.

Most synthetic sorbents float so that they can be considered for spills on both water and land. Because spilled substances can usually be contained more readily on land, however, sorbents are often more effective in that situation. This is particularly true of particulate sorbents which, when used on land, can be harvested by earth-moving machinery or other equipment to hasten the cleanup process. On the other hand, operational difficulties can arise if they are indiscriminately broadcast on floating materials without prior containment having been considered.

In the case of granules, particulates and other loose forms of sorbent, information on inhalation toxicity and skin sensitivity should be requested insofar as the initial distribution of the sorbent is concerned. Precautions such as coveralls and face masks may be required when such materials are applied.

Again, consult the manufacturer for specific operational advice including storage requirements, safety concerns, application methods and disposal alternatives. In the latter regard, regulatory authorities should always be consulted for ultimate disposition of used sorbents containing hazardous materials.

STATUS OF DEVELOPMENT AND USAGE – A wide range of commercial products is marketed world-wide. Several of these have been explicitly developed for the recovery of hazardous materials. See also separate entries in this section. Most were originally sold for oil spill cleanup although compatibility of many sorbents with certain hazardous materials is now noted.

PERFORMANCE – Although limited evaluation of sorbents has been conducted on hazardous materials both on spills and in the laboratory, the U.S. EPA has compiled a report which offers guidance on the subject. A summary table has been reproduced here.

AVAILABILITY AND COMMERCIAL INFORMATION – Contact information is presented in separate entries in this section for the following sorbents (their use has been specifically denoted by the manufacturer for hazardous material spills):

Absol Sorbent
Conwed D Sorbent Pads
Hazorb Sorbent
Petro-trap Sorbent
Safestep Sorbent
Spill Control Pillows

OTHER DATA – The report referenced above under Availability and Commercial Information contains performance data for sorbents tested with fresh and aged crude oil, diesel and Bunker C. Since sorption capacity is in part dependent upon viscosity, the results should indicate trends for various hazardous materials – assuming compatibility has been determined.

References: Henick, E.C., D. Carstea, and G. Goldgraben, "Sorbent Materials for Cleanup of Hazardous Materials", Report EPA-600/2-82-030, U.S. Environmental Protection Agency, Cincinnati, OH, (March, 1982) (see also Project Summary EPA-600/S2-82-030 dated July 1982 under same authorship, title).

Robertson, L.A., Selection Criteria and Laboratory Evaluation of Oil Spill Sorbents: Update II, Report EPS 4-EP-83-4, Environment Canada, Ottawa, Ontario (November, 1983).

CAPABILITY OF HAZARDOUS LIQUIDS AND SELECTED SORBENT MATERIALS

Hazardous Liquids	Sorbent Materials	ANIMAL MATERIALS^{a}	CARBON ACTIVATED	CELLULOSE^{b}	CELLULOSE, CONWED^{c}	MINERALS, CALCIUM CARBONATE	MINERALS, OTHER^{d}	MINERALS, TREATED HAZORB^{e}	Perlite and Cellulose, Treated	Polypropylene		OTHER POLYOLEFINS	Polyurethanes			IMBIBER BEADS^{m}	MULTIPURPOSE GELLING AGENT
									Fiberperl^{f} Sorbent C^{g}	3M Oil Sorbent^{h}	Oil Snare^{j} Quick-Wick^{l}		Graboil^{k}	Petro-Trap^{i}	SSC Absorbent^{m}		
Acids and Derivatives	Acetic acid	-	A	-	AP	-	A	-	-	A	-	-	-	-	-	-	A
	Acetic anhydride	-	A	-	AP	-	A	13	-	A	-	-	-	-	-	-	A
	Butyric acid	-	A	A	A	-	A	-	-	A	-	-	-	-	-	A	A
	2, 2-Dichloropropionic acid	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Formic acid	-	A	-		-		-	-		-	-	-	-	-	-	A
	Naphthenic Acid	-	A	-	A	-		-	-	-	-	-	-	-	-	-	A
	Propionic acid	-	A	-	A	-		-	-	-	-	-	-	-	-	-	A
	Propionic anhydride	-	A	-	-	-	-	-	-	A	-	-	-	-	-	-	-
Alcohols and Phenols	Allyl alcohol	-	A	-	A		-	10	-	A	-	-	-	-	-	-	-
	Cresol	-	A	A	A	-		13	-	A	-	A	-	-	A	A	A
	Phenol	-	A	A		-		15	-	-	-	-	-	A	-	-	A
Aldehydes and Ketones	Acetaldehyde	-	A	-	A	-		11	-	A	A	-	-	A	-	-	A
	Acrolein	-	A	-	A	-	-	-	-		-	-	-	-	-	-	-
	Crotonaldehyde	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Formaldehyde	-	A	x^{l}	x	-		10	-	A	-	-	-	-	-	-	A
	Furfural	-	A	-	P	-		-	-	A	-	-	-	-	-	-	A
Epoxides	Propylene oxide	-	A	-	-	-		-	-	A	-	-	-	-	-	-	A
Esters	Amyl acetate^{s}	-	A	A	P	-	-	9	-	A	A	A	-	-	A	-	-
	Butyl acetate	-	A	A	A	-		11	-	A	A	A	-	-	A	-	A
	n-Butyl phthalate	-	A	-	-	-		-	-	A	-	-	-	-	-	-	A
	Methyl methacrylate^{s}	-	A	A	A	-		11	-	A	A	A	-	-	A	-	A
	Pyrethrina	-	-	-	-	-	-	-	-	A	-	-	-	-	-	-	-
	Vinyl acetate	-	A	A	P	-		8	-	A	A	A	-	-	A	-	A
Halogen Compounds	Acetyl bromide	-	A	-	A	-	-	-	-	A	-	-	-	-	-	-	-
	Acetyl chloride	-	A	-	A	-	-	-	-	A	-	-	-	-	-	-	-
	Allyl chloride	-	A	A	A	-	-	-	-	A	A	A	-	-	A	-	-
	Benzoyl chloride	-	A	-	-	A	-	-	-	A	-	A	-	-	A	-	-
	Benzyl chloride	-	A	-	-	A	A	-	-	A	-	-	-	-	-	A	A
	Carbon tetrachloride	-	A	-	-	-	A	19	-	A	-	-	-	-	-	A	A
	Chlordane	-	A	-	-	-	-	-	-	A	-	-	-	-	-	-	-
	Chlorobenzene	-	A	-	A^{P}	-	A	12	-	A	-	-	-	-	-	A	A
	Chloroform	-	A	-	A^{P}	-	A	12	-	18	A	A	-	-	A	A	A
	Cyanogen chloride	-	A	-	A	-	-	-	-	-	-	A	-	-	A	-	-
	o-Dichlorobenzene	-	A	-	-	-	A	-	-	-	-	-	-	-	-	A	A
	Dichloropropene-	-	A	-	-	-	-	-	-	A	-	-	-	-	-	A	-
	dichloropropane (D-D mixture)	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2, 2-Dichloropropionic acid	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Hexachlorocyclopentadiene	-	-	-	-	-	-	-	-	A	-	-	-	-	-	A	-
	Phosgene	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Polychlorinated biphenyls (PCBs)	-	A	-	-	-	A^{ee}	10	-	A	-	A	-	-	-	-	A
	Trichloroethylene	-	A	-	-	-	A	13	-	A	-	-	-	-		A	A
	Vinylidene chloride	-	A	-	-	-	-	-	-	A	-	-	-	-	-	-	-
Hydrocarbons	Benzene^{s}	-	A	A	A	-	A	11	6	10	A	-	14	19	A	A	A
	Cyclohexane^{s}	-	A	A	A	-	A	7	-	A	A	-	-	-	-	-	A
	Ethylbenzene^{s}	-	A	A	A	-	A	9	-	A	A	A	-	-	A	A	A
	Isoprene^{s}	-	A	A	A	-	A	-	-	A	A	A	-	-	-	A	A
	Styrene^{s}	-	A	A	A	-	A	9	-	A	A	-	-	-	A	A	A
	Toluene^{s}	-	A	A	A^{P}	-	1	11	-	A	A	A	-	-	A	A	A
	Xylene^{s}	-	A	A	A^{P}	-	1	11	-	A	A	A	-	-	A	A	A
Nitrogen Compounds	Acetone cyanohydrin	-	A	-	A	-	A	-	-	A	-	A	-	-	-	-	A
	Acrylonitrile	-	A	A	A	-	A	10	-	A	-	-	-	-	A	-	A
	Aniline	-	A	-	A	-	A	17	-	A	-	-	-	-	-	-	A
	Benzonitrile	-	A	-	A	-	-	-	-	A	-	-	-	-	-	-	-
	Butylamine	-	A	-	A	-	A	-	-	A	-	-	-	-	-	-	A
	Diethylamine	-	A	-	A	-	A	6	-	A	A	A	-	-	A	-	A

Nitrogen Compounds (Cont'd)	Dimethylamine	-	A	-	-	-	-	-	-	A	A	-	-	-	A	-	-
	Dinitrotoluene	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Ethylenediamine	-	A	-	-	-	A	-	-	A	-	-	-	-	A	-	A
	Hydrogen cyanide	-	A	-	-	A	A	-	-	-	-	-	-	-	-	-	-
	Monoethylamine	-	A	-	A	-	A	-	-	A	-	-	-	-	-	-	A
	Nitrobenzene	-	A	-	A	-	A	-	-	A	-	-	-	-	-	-	A
	Quinoline	-	A	-	A	-	-	-	-	A	-	-	-	-	-	-	-
	Triethylamine	-	A	-	A	-	A	-	-	-	-	A	-	-	A	-	A
	Trimethylamine	-	A	-	A	-	A	-	-	A	-	-	-	-	-	-	A
Organometallic Compounds	Tetraethyl lead	-	A	-	A	-	A	-	-	A	-	-	-	-	-	-	-
Organophosphorus Compounds	Diazinon	-	A	-	-	-	A	-	-	A	-	-	-	-	-	-	A
	Dichlorvos	-	A	-	-	-	A	-	-	A	-	-	-	-	-	-	A
	Disulfoton	-	A	-	-	-	A	-	-	A	-	-	-	-	-	-	A
	Ethion	-	A	-	-	-	A	-	-	A	-	-	-	-	-	-	A
	Malathion	-	A	-	A	-	A	-	-	A	-	-	-	-	-	-	A
	Methyl parathion	-	A	-	-	-	A	-	-	-	-	-	-	-	-	-	A
	Mevinphos	-	A	-	-	-	A	-	-	A	-	-	-	-	-	-	A
	Naled	-	A	-	-	-	A	-	-	A	-	-	-	-	-	-	A
	Parathion	-	A	-	-	-	A	-	-	A	-	-	-	-	-	-	A
	Tetraethyl pyrophosphate	-	A	-	-	-	-	-	-	A	-	-	-	-	-	-	-
Sulphur Compounds	Carbon disulphide	-	A	-	A	-	A	-	-	A	-	-	-	-	-	-	A
	Chlorosulphonic acid	-	A	-	-	-	A	-	-	A	-	-	-	-	-	-	A
	Methyl mercaptan	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	A
Acids	Hydrochloric acid	x	A	x	x	A[t]	A	14	-	A	-	-	-	-	-	-	-
	Hydrofluoric acid	x	A	x	x	A[t]	A	-	-	-	-	-	-	-	-	-	-
	Nitric acid	x	A	x	x	A[t]	A	20	-	A	-	-	-	-	-	-	-
	Phosporic acid	x	A	x	x	A[t]	A	26	-	A	-	-	-	-	-	-	-
	Sulphuric acid	x	A	x	x	A[t]	A	19	-	A	-	-	-	-	-	-	A
Inorganic Halides	Antimony pentachloride	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Arsenic trichloride	-	A	-	-	-	-	-	-	A	-	-	-	-	-	-	-
	Phosphorous oxychloride	-	A	-	-	A	-	-	-	A	-	-	-	-	-	-	-
	Phosphorous trichloride	-	A	-	-	A	-	-	-	A	-	-	-	-	-	-	-
	Sodium hypochlorite (solution)	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Sulphur monochloride	-	A	-	-	-	-	-	-	A	-	-	-	-	-	-	-
	Zinc chloride	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other	Ammonium hydroxide	-	A	-	-	-	-	12	-	-	-	-	-	-	-	-	A
	Nitrogen dioxide	-	A	-	-	A	-	-	-	-	-	-	-	-	-	-	-

A represents compatible combinations as per referenced literature
- indicates data were available
Numbers represent absorption capacity (mass of material sorbed per unit mass of sorbent), based on experimental data.

[a] Wool, feathers, leather shavings.
[b] Bark, hulls, peat moss, sawdust, straw.
[c] Proprietary product of Conwed Corporation. Information is abstracted from company's advertising materials.
[d] Ash, clays, perlite, sand vermiculites.
[e] Proprietary product of Diamond Shamrock Corporation.
[f] Proprietary product of Grefco, Inc.
[g] Proprietary product of Clean Water, Inc.
[h] Proprietary product of 3M Company. Information is abstracted from company's advertising materials.
[i] Proprietary product of Parker Systems, Inc.
[j] Proprietary product of Clark-Cutler-McDermott Company.
[k] Proprietary product of RBH Cybernetics, Ltd.
[l] Proprietary product of Best Textile Company.
[m] Proprietary product of Sorbent Sciences Corporation.
[n] Proprietary product of Dow Chemical Company.
[p] Conclusion based on experimental data.
[r] "x" Represents incompatible combinations.
[s] Insoluble floater.

PRODUCT ABSOL ABSORBENT AND FLAME RETARDANT **No. 47**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – Absol is granular monocalcium silicatehydrate formulated for application on land to spills of chemicals and petroleum products as a sorbent, neutralizing agent and flame retardant.

OPERATING PRINCIPLE – The sorbent is poured on the released substance which is both absorbed physically and adsorbed via weak chemical bonding to the microcellular structure and large surface area.

PHYSICAL SPECIFICATIONS –

Sorbent Material principally monocalcium silicatehydrate
Packaging 35-L bags
Shelf-Life 50 years
Surface Area 30 m^3/g (sand = 1 m^2/g)

OPERATING SPECIFICATIONS – The manufacturer states that Absol achieves greater than 60% by volume absorption, is capable of removing films, and helps to contain fumes. It will not burn following chemical pickup.

STATUS OF DEVELOPMENT AND USAGE – Absol was reported as a new, commercially available product in the October 1983 edition of Hazardous Cargo Bulletin. Documentation of usage on hazardous material spills was not obtained.

PERFORMANCE – The manufacturer reports that Absol was applied to nitric acid leaving 3 to 5% residual acid and 0.5 ppm nitrous oxide ("2 ppm is the hygiene threshold limit and 5 ppm is the ceiling".). By contrast, clays and volcanic stone left 80 to 90% residual acid and silicates left 18 to 70%.

The very high available surface area should render Absol effective on minor amounts of spilled chemicals given compatibility between the sorbent and released substance as well as no interferences with optimal contact (such as wind, water application, ground penetration or excessive runoff of product).

AVAILABILITY AND COMMERCIAL INFORMATION –

UK Distributor:
TOPP Hygienics Ltd.
Balcombe Road
Horley, Surrey RH6 9ET
U.K.

OTHER DATA – Absol originated in Sweden where, it is claimed, it is widely used by industry and fire services.

PRODUCT CONWED D-SORBENT PADS **No. 48**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – Polymeric foam pad for the sorption and retention of spilled oil and chemicals.

OPERATING PRINCIPLE – Pads of sorbent material are placed in or on the spill. After use, the pad may be "wrung out" to recover the sorbed product.

PHYSICAL SPECIFICATIONS – Sorbent Material: modified, low density polyethylene foam; slightly abrasive 533 mm square x 6 mm (21 in square x 0.24 in) thick.

OPERATING SPECIFICATIONS – Will pick up to 23 times its weight in petroleum products. See General Listing for compatibility with chemicals in addition to:

Chemical	For use on Water/Land
Acetaldehyde	no/yes
Acetic Acid (glacial)	no/yes
Acetic Anhydride	no/yes
Acetone	no/yes
Acetone Cyanohydrin	no/yes
Acetyl Bromide	no/yes
Acetyl Chloride	no/yes
Acrylonitrile	yes/yes
Acrolein	yes/yes
Allyl Alcohol	no/yes
Allyl Chloride	yes/yes
Aminotoluene (benzylamine-toluidine)	no/yes
Amyl Acetate	no/yes
Aniline	yes (immerse)/yes
Benzene	yes/yes
Benzonitrile	yes (immerse)/yes
n-Butyl Acetate	yes/yes
Butyl Amine	no/yes
Butyric Acid	yes/yes
Carbon Bisulphide	yes (immerse)/yes
Carbon Tetrachloride	yes (immerse)/yes
Chlorobenzene	yes (immerse)/yes
Chloroform	yes (immerse)/yes
Cresol	yes (immerse)/yes

Cyclohexane	yes/yes
Diethyl Amine	no/yes
Ethylamine	no/yes
Ethylbenzene	yes/yes
Formic Acid	no/yes
Furfural	no/yes
Isoprene	yes/yes
Malathion	yes (immerse)/yes
Methyl Methacrylate	yes/yes
Nitrobenzene	yes (immerse)/yes
Perchloroethylene	yes (immerse)/yes
Phenol (carbolic acid)	no/yes
Polyethylbenzene	
Propionic Acid	no/yes
Propyl Alcohol	no/yes
Quinoline	no/yes
Styrene (monomer)	yes/yes
Tetraethyl Lead	yes (immerse)/yes
Toluene (toluol)	yes/yes
1,1,1, Trichloroethane	yes (immerse)/yes
Vinyl Acetate (monomer)	yes/yes
Xylene (xylol)	yes/yes

STATUS OF DEVELOPMENT AND USAGE – Commercial product used in Canada and the U.S. in oil spill cleanup. Documentation of usage on hazardous material spills was not obtained although the manufacturer has provided a comprehensive indication of chemical compatibility.

PERFORMANCE – Evaluations on petroleum products indicate that approximately 15 g oil are picked up per g sorbent for fresh and weathered diesel, crude and Bunker C (i.e., for a wide range of viscosity). Similar results could be expected for other spilled substances.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:	Distributor:
Conwed Corporation Sorbent Products 332 Minnesota Street P.O. Box 43237 St. Paul, MI 55164 U.S.A. Telephone (612) 221-1144	Sorbco 5369 Maingate Drive Mississauga, Ontario Canada L4W 1G3 Telephone (416) 624-1264

OTHER DATA – Conwed manufactures a range of sorbent products in various materials and formats. Original marketing efforts centered around the company's cellulosic sorbent reinforced with a polypropylene net which has been used on oil spill cleanup but also has application to certain hazardous materials.

References: Manufacturers' Literature; Robertson, L.A., Selection Criteria and Laboratory Evaluation of Oil Spill Sorbents: Update II, Environment Canada, Ottawa, Ontario, Report EPS 4-EP-83-4 (November, 1983).

PRODUCT HAZORB **No. 49**

APPLICABILITY	Gas	Liquid			Solid		
		Sol	Fl	Sk	Sol	Fl	Sk
		*	*	*			

DESCRIPTION – A treating agent which can be used to pick up spills on land and to control vapours. It consists of sodium silicate foam granules contained in an inert porous fabric pillow.

OPERATING PRINCIPLE – The sorption of liquids by this material is a physical process. Liquids are absorbed by the Hazorb material. It cannot be applied to spills in water since Hazorb itself will absorb water.

PHYSICAL SPECIFICATIONS –

Form: White granules, 8 to 200 mesh
Packaging:
  Polypropylene construction pillows
  Size: 432 x 660 x 51 mm (17 x 26 x 2 in)
  Volume: 0.01 m^3 (0.5 ft^3)
  Weight: Approximately 0.5 kg (1 lb)

Toxicity:
  Acute inhalation toxicity: LC$_{50}$ 2.32 mg/L air
  Acute oral toxicity: LD$_{50}$ 15 380 mg/kg
  Mild eye irritant (19.7/110.0)
  Slight skin irritant (0.7/8.0)
  Not a skin sensitizer
  Shelf-Life: Indefinite

OPERATING SPECIFICATIONS –

Non-combustible and non-draining.
Can absorb up to 20 times its weight.
Not recommended for use on hydrofluoric acid.
Strong oxidizing chemicals will degrade the polypropylene pillow fabric but not the sorbent.

STATUS OF DEVELOPMENT AND USAGE – Commercial product specifically conceived for application to hazardous material spills. Documentation of usage on accidental releases not obtained although the manufacturer maintains an extensive customer list of U.S.-based companies.

PERFORMANCE – The following absorption results were obtained from tests made by immersing the sorbent in liquid for 15 minutes, draining for 5 minutes and then measuring the quantity absorbed:

	Volume L/10 kg
Acids	
Acetic Acid (Glacial)	10.8
Boric Acid, 6% @ 90°F	15.8
Boric Acid, 12% @ 140°F	15.0
Chlorosulphonic Acid	11.7
Chromic Acid, 20%	15.0
Chromic Acid, 60%	13.3
Formic Acid	15.0
Hydrochloric Acid, 38%	13.3
Nitric Acid, 71%	11.7
Nitric Acid, Fuming	12.5
Oleum, Fuming Sulphuric	17.5
Phosphoric Acid, 83%	15.0
Sulphuric Acid, 98%	14.2
Agricultural Chemicals	
Dacamine (N-Oleyl 1,3-propylenediamine salt of 2,4-Dichlorophenoxyacetic Acid, 2 lb/gal)	14.2
Dacamine 4D (N-Oleyl 1,3-propylenediamine salt of 2,4-Dichlorophenoxyacetic Acid, 4 lb/gal)	14.2
Daconate 6 (Monosodium Methylarsenate)	15.0
Alcohols and Ethers	
Ally Alcohol	13.3
Diethyl Ether	9.2
Ethanol	9.2
Ethylene Glycol	14.2
Glycerine	15.8
Isopropanol	10.8
Methanol	10.0
Alkalies	
Ammonium Hydroxide, 30%	15.0
Caustic Potash, 45%	16.7
Caustic Potash, 10%	15.0
Caustic Soda, 50%	20.0
Caustic Soda, 10%	15.0
Sodium Methoxide in Methanol, 25% Liquid	15.0
Amines	
Aniline	16.7
n-Butylamine	13.3
Diethylamine	10.0
Ethylenediamine	17.5
Triethanolamine	18.3
Triethylamine	13.3
Aromatics	
Benzene	14.2
Benzonitrile	15.0
Benzoyl Chloride	12.5
Chlorobenzene	11.7
Cresol	14.2
O-Dichlorobenzene	13.3
Ethyl Benzene	11.7
Nitrobenzene	15.0
Phenol, 84%	15.8
Toluene	12.5
Xylene	10.0
Chlorinated Hydrocarbons	
Chlorowax LV	17.5
Chlorowax 40	15.8
Chlorowax 42-170	15.8
Chlorowax 50	20.0
Chlorowax 100	17.5
Chlorowax 500-C	18.3
PCB (Polychlorinated Biphenyl)	8.3
Chlorinated Solvents	
Carbon Tetrachloride	8.3
Chloroform	9.2
Ethylene Dichloride	10.8
Methylene Chloride	10.0
Perclene D (Perchloroethylene)	10.0
Triclene D (Trichloroethylene)	10.0
Hydrocarbons	
Cyclohexane	10.0
Gasoline	9.2
Fuel Oil, No. 2	13.3
n-Hexane	12.5
Mineral Spirits	10.0
Motor Oil, SAE No. 40	18.3
Ketones, Aldehydes & Esters	
Acetaldehyde	15.0
Acetone	10.8
Amyl Acetate	11.7
n-Butyl Acetate	13.3
Dioctyl Phthalate (DOP)	15.8

	Volume L/10 kg
BYX (Benzene/Toluene/Xylene)	14.2
Methyl Methacrylate	12.5
Vinyl Acetate	9.2
Salts	
Alum, 50% liquid	13.3
Ferric Chloride, 40%	15.0
Potassium Carbonate, 47%	15.8
Sodium Bichromate, 70%	15.0
Sodium Sulphate, (18%)	18.3
Silicates	
Sodium Silicate Gr 40 Liq.	18.3
Sodium Silicate Gr 52 Liq.	16.7
Surfactants	
Bional A-50, cationic, (GAF)	19.2
Monawet SNO-35, Anionic, (Mona Industries)	19.2
Tergitor 15-S-12, Nonionic, (Union Carbide)	18.3
Vegetable Oils	
Corn Oil	16.7
Peanut Oil	17.5
Safflower Oil	17.5
Soybean Oil	17.5
Miscellaneous	
Acetic Anhydride	13.3

	Volume L/10 kg
Formaldehyde, 37%	10.0
Methyl Ethyl Ketone	9.2
Acrylonitrile	13.3
Allyl Chloride	13.3
Bromine	8.3
Carbon Disulphide	10.8
Epichlorohydrin	15.8
Heat Transfer Liquid, Dowtherm A	15.0
Hydrazine Hydrate (85% Sol.)	13.3
Hydrogen Peroxide, 30%	10.0
Isophorone	14.2
MEK Peroxide in Dimethyl Phthalate, 60%	11.7
Methyl Isocyanate	12.5
Oil/water Emulsion, 75% Petroleum Lubricating Oil	22.5
Phosphatizing Solution	12.5
Phosphorus Trichloride	10.0
PVC Latex (40% Solids)	12.5
Scintillation Liquid So-X-1 Scintiverse (Fisher Scientific Co.)	15.0
Scintillation Liquid (PPO, POPOP, Xylene, Naphthalene, Dioxane, Ethoxyethanol)	13.3
Silane Coupling Agent	11.7
Silicone Emulsion SM 2085, General Electric Company	12.5
Silicone Transformer Liquid, Dow Corning 561	14.2
Styrene	10.8
Tetrahydrofuran	11.7
Titanium Tetrachloride	10.8
Toluene Diisocyanate	12.5
Water/Oil Emulsion, 5%	17.5
Petroleum Lubricating Oil	17.5
Water Repellant No. 772, Dow Corning	18.3

Also tested for vapour emissions control from gasoline, acetone, diethyl ether; lab experiments using a cover of 40 g (1.4 oz) of solvent per 200 g (7 oz) of liquid reduced vapour emissions by 50 to 90%.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:
Diamond Shamrock Corporation
Soda Products Division
351 Phelps Court, P.O. Box 2300
Irving, TX 75061
U.S.A.
Telephone (214) 659-7000

Canadian Distributor:
Sanivan Inc.
1705 3e Ave.
Pointe-aux-Trembles
Montreal, Quebec
H1B 5M9
Telephone (514) 353-9170
Telex: 05-829559; Contact: Pierre Richard

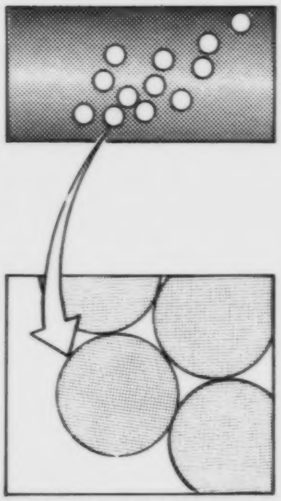
OTHER DATA – Claimed to have indefinite shelf-life. For ultimate disposal methods, approval by regulatory authorities should be sought.

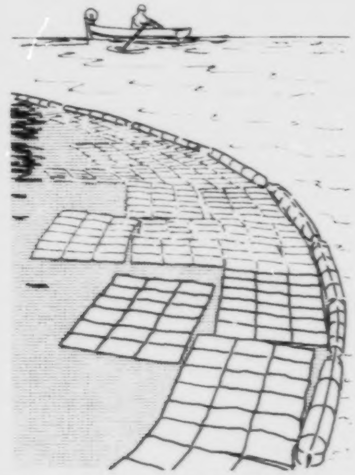
Reference: Manufacturer's Literature; Temple, R.E., R.J. Estherhay, W.T. Gooding, and G.F. Bennett, Diamond Shamrock Corporation: "A Universal Sorbent for Hazardous Spills", Journal of Hazardous Materials, 4 pp. 185-190 (1980).

PRODUCT IMBIBER BEADS **No. 50**

APPLICABILITY	Gas	Liquid			Solid		
		Sol	Fl	Sk	Sol	Fl	Sk
		*	*	*			

DESCRIPTION – Imbiber Beads are polymeric spheres which absorb a variety of organic fluids, including gasoline, fuel oil, chlorinated solvents, PCBs, aromatic solvents (e.g., benzene, styrene), and many polar compounds (methylisobutyl ketone, ethyl acrylate). Imbiber beads will not adsorb water (hydrophobic), solids (unless dissolved into solution), high viscosity oils (unless thinned), low molecular weight alcohols, glycols, acetic acid, acetonitrile, nitromethane, and other highly polar materials.





OPERATING PRINCIPLE – The beads consist of lightly cross-linked polymer chains which swell when contacted with an organic solvent. The liquid is entrapped by the molecular structure of the polymer.

PHYSICAL SPECIFICATIONS – Cross-linked polymers of T-butyl-styrene; bead diameters not available.

OPERATING SPECIFICATIONS – Depending on the solvent properties of the fluid and the polymer formulation, adsorption of up to 27 times the original bead volume is possible. The entrapped fluid cannot be squeezed from the beads once imbibed. A bead will not leak fluid if crushed or cut after full adsorption. The beads become sticky until saturation equilibrium is reached.

STATUS OF DEVELOPMENT AND USAGE – Used in commercial products such as gelling agents (see "EPA Multipurpose Gelling Agent" in this survey), adsorbent blankets (for spills and shipment of liquid samples) and valves for draining water from storage tanks without losing stored organic liquids.

PERFORMANCE – Recommended uses include adsorbing spills on land or in waterways, containing spills in diked areas, or in safety shutoff valves which close when exposed to organic liquids.

Oil loss from an experimental silica sand bed (to simulate a shallow burial system infiltrated by water) was 34% versus 0.02% from a bed of Imbiber Beads/Wick mixture over an 18-day test period. The oil mixture buried in the beds was 91% Mobile DTE turbine oil with 9% No. 2 fuel oil.

When loaded with Cobalt Nitrate, the above mentioned oil experiment showed no detectable cobalt in the leachate from the Imbiber beads during a 20-day test, whereas over 35% of the available Cobalt leached from the sand during the first ten days.

AVAILABILITY AND COMMERCIAL INFORMATION – Dow sold the patent and distribution rights for their Imbiber Beads to ENSCO (Energy System Co., El Dorada, Arkansas) in September 1981. EMCO, Inc., a subsidiary of ENSCO, is now manufacturing the beads.

EMCO Inc.	Distributor:
1015 Louisiana St.	
Little Rock, AR 72207	Anco Chemicals Limited
U.S.A.	P.O. Box 400
Telephone (501) 374-7878	Maple, Ontario
Contact: Mr. Allen Marshall	Canada
or Mr. Jack McLachlan	L0J 1E0
	Telephone (416) 832-2276

OTHER DATA – EMCO has modified Dow Imbiber Beads so that three types are available to absorb: 1) non-polar organics; 2) polar organics; and 3) aqueous solutions. A combination of these beads and ground polyethylene wicking agent contained in a spun-bonded, polypropylene, quilted blanket was commercially introduced in 1983.

The blankets are available in 35 x 53 cm (14 x 21 in) and 53 x 106 cm (21 x 42 in) sizes, capable of absorbing up to 3.8 L and 11.3 L (1 and 3 USG) respectively. EMCO claims the blankets will absorb PCBs, solvents, ketones, acids, and alkalis, but not strong oxidizing agents.

References: "Arkansas firm to market new blanket to absorb hazardous liquid spills." Hazardous Materials Intelligence Report (April 3, 1983).

"EMCO Imbiber Beads", Oil Spill Intelligence Report p. 3 (March 25, 1983).

D.H. Haigh, "Dow Imbiber Beads for Oil Waste Immobilization", Dow Chemical Company, Central Research, Physical Research Laboratory, Report B600-CC9-79.

PRODUCT PETRO-TRAP **No. 51**

APPLICABILITY	Gas	Liquid			Solid		
		Sol	Fl	Sk	Sol	Fl	Sk
		*	*	*			

DESCRIPTION – Packaged sorbent media for absorbing spilled materials.

OPERATING PRINCIPLE – Sorbent material is enclosed in a polypropylene membrane which excludes water but allows other substances to pass through. The sorbent material then absorbs the spilled material. The Petro-Trap may be put through a wringer in order to recover the spilled product.

PHYSICAL SPECIFICATIONS – Cover: Spun-bonded polypropylene; Sorbent: Die-cut polyurethane; Dimensions:

A	Commercial	457 x 762 x 76 mm	(18 x 30 x 3 in)
B	Trucker	229 x 762 x 76 mm	(9 x 30 x 3 in)
C	Pit Boss	229 x 356 x 76 mm	(9 x 14 x 3 in)
D	Drip Pad	406 x 610 x 25 mm	(16 x 24 x 1 in)
E	Hand Pad	127 x 152 x 13 mm	(5 x 6 x 0.5 in)
F	Slick Pad	406 x 610 x 25 mm	(16 x 24 x 1 in)
G	G-Boom	229 x 1219 x 76 mm	(9 x 48 x 3 in)
G	G-Boom	229 x 2438 x 76 mm	(9 x 96 x 3 in)
	Box	114 x 102 x 152 mm	(4.5 x 4 x 6 in)
	Bundle	381 x 381 x 762 mm	(15 x 15 x 30 in)
	Case	559 x 737 x 279 mm	(22 x 29 x 11 in)

Wringer: 457 mm rollers, 6 hp, 12 V motor

OPERATING SPECIFICATIONS – Compatibility is indicated with certain hazardous materials as well as petroleum products. Application on water and on land is possible as well as reuse.

STATUS OF DEVELOPMENT AND USAGE – Commercial product. Usage on hazardous materials has been indicated by manufacturer only to a limited extent.

PERFORMANCE – Tests performed for Petro-Trap indicated these pick-up capabilities:

Chemical	Sorption Capacity (g/g) (tests at room temperature)
Ethyl Ether	8.9
Kerosene	13.9
n-Amyl Alcohol	20.9
Naphtha	9.8
Ethyl Acetate	14.3
Hexane	9.4
Butyraldehyde	13.8
Benzene	18.8

Product appears to be more durable than most other sorbents.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Petro-Trap
P.O. Box 91
Westport, MA 02790 U.S.A.
Telephone (617) 675-7831
Contact: Mr. R.J. Von See

OTHER DATA – The manufacturer also markets an electric wringer to squeeze out sorbed material when circumstances make sorbent reuse feasible.

PRODUCT SAFESTEP SORBENT **No. 52**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – An inert, inorganic sorbent of silicones and other minerals containing no free silica formulated to be insoluble in most solvents and strong mineral acids as it picks up and retains these.

OPERATING PRINCIPLE – The small particle size of this sorbent presents a large surface area to spilled chemicals which are adsorbed on contact when Safestep is spread on and mixed with the discharged material.

PHYSICAL SPECIFICATIONS – Average Particle Size - 0.030 mm; packaging - 11.3 kg (25 lb) heavy duty, multi-wall bags; material - blend of silicones and other minerals; properties - insoluble in water, inert, nonflammable

OPERATING SPECIFICATIONS – For application to petro-chemicals, acids, caustic solutions, organics, inorganics, PCBs and other toxic and hazardous wastes. Insoluble in most solvents and strong mineral acids except hydrofluoric acid. Harmless to skin and clothing. Should be spread on and mixed with spilled material to ensure maximum sorption.

STATUS OF DEVELOPMENT AND USAGE – Commercial product specifically for the treatment of hazardous material spills. Documentation of usage was not obtained.

PERFORMANCE – The manufacturer refers to the U.S. EPA's Final PCB Ban Rule of June 1979, p. 28, and independent tests conducted by Analytical Research Laboratories, Inc., Monrovia, CA in claiming that Safestep retrieves significantly more PCB-contaminated oil than other sorbents and is particularly suited for that purpose. No other evaluation data were obtained. Because of the small particle size, it is anticipated that application of the sorbent would have to be undertaken with due attention paid to winds and other potential interfering factors.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer: Andesite of California, Inc.
1260 South Goodrich Boulevard
Los Angeles, CA 90022
U.S.A.
Telephone (213) 726-7602

OTHER DATA – As the manufacturer claims, Safestep should adsorb material immediately on contact. It should prove effective on minor amounts of spilled material to which a sorbent can be readily applied, mixed and collected.

PRODUCT SPILL CONTROL PILLOWS **No. 53**

APPLICABILITY	Gas	Liquid			Solid		
		Sol	Fl	Sk	Sol	Fl	Sk
		*	*	*			

DESCRIPTION – Polyolefin pillows which entrap acids, caustics, and organic solvents by foamed particles contained inside.

OPERATING PRINCIPLE – Amorphous silicate particles are foamed and act like sponges to absorb liquids into the pillow.

PHYSICAL SPECIFICATIONS – Amorphous silicate absorbent contained in a porous polyolefin pillow. Available in three absorbent capacities: 250 mL (9 oz); 1 L (0.3 U.S. gal); and 4 L (1 U.S. gal).

OPERATING SPECIFICATIONS – Pillows claimed to absorb 98% of their capacity in 30 seconds. Pillows will absorb 10 to 20 times their own weight of most hazardous liquids, except hydrofluoric acid. Saturated pillows can be treated by elution, evaporation, incineration or landfill disposal.

STATUS OF DEVELOPMENT AND USAGE – Commercially available for laboratory and small industrial spills of hazardous materials.

PERFORMANCE – Test results regarding the use of the pillows with specific hazardous liquids has not been documented, except for their incompatibility with solutions containing hydrofluoric acid.

AVAILABILITY AND COMMERCIAL INFORMATION –

Available through: Lab Safety Supply
P.O. Box 1368
Janesville, WI 53547-1368
U.S.A.
Telephone 1-800-356-0783
TWX 910-288-2921

OTHER DATA – Disposal bags, racks and dispenser-type cartons are available from the manufacturer.

2.5 Dredging

PRODUCT DREDGING EQUIPMENT - GENERAL LISTING **No. 54**

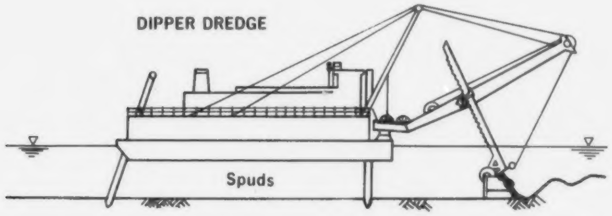
Acknowledgement

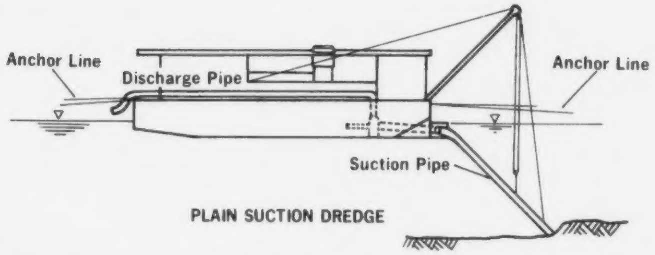
The information contained in this entry is based on the Noyes Data Corporation 1979 publication "Hazardous Chemical Spill Cleanup" edited by J.S. Robinson. The particular section referenced (pages 122-133) was, in turn, based on "A Feasibility Study of Response Techniques for Discharges of Hazardous Chemicals that Sink", CG-D-56-78 prepared by T.D. Hand, A.W. Ford, P.G. Malone, D.W. Thompson and R.B. Mercer of the U.S. Army Engineer Waterways Experiment Station for the U.S. Coast Guard.

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
			*			*

DESCRIPTION – Mechanical equipment utilizing various principles typically employed for underwater excavation to deepen watercourses for navigation or for underwater mining or for the collection of benthos. Application of such devices to hazardous material spill response has also been made albeit to a limited extent.





OPERATING PRINCIPLE – Dredges can be classified into four groups according to the means of moving material, pumping system and/or purpose. (Note that other categorizations are also possible such as the method used to store or deposit dredged material, the device selected to excavate sediments, etc.):

1) **Mechanical Dredges** – Mechanical force is directly applied to dislodge and excavate material at almost in-situ densities. Most such dredges deposit dredged material into scows or barges for transportation to a disposal site. Specific types include the dipper, bucket ladder and grab or clamshell.

2) **Hydraulic Dredges** – Usually barge-mounted so that they can both remove and transport sediment in liquid slurry form. Diesel or electric-powered centrifugal pumps are used with discharge pipes 15.2 to 122 cm (6 to 48 in) in diameter to transport slurries containing 10 to 20% solids by weight. Pontoon-supported pipelines can traverse several thousand metres to reach a land-based disposal site. Dredged material can also be handled via sidecasting, loading into barges or scows, and direct loading of on-board hoppers. xamples are plain suction, dustpan, cutterhead and hopper dredges.

3) **Pneumatic Dredges** — A pump operates on compressed air and hydrostatic pressure handling slurries to 70% of the in-situ density. Data on percent solids by weight are unavailable. These hydraulic pipeline systems were originally developed in Italy under the trade name Pneuma.

4) **Special Purpose Dredges** — Various devices could be used for recovering spilled hazardous materials from water including hand-held suction units, portable pumping systems and specially designed machines such as the Mudcat, a scaled-down hydraulic dredge (see separate entry this section).

PHYSICAL SPECIFICATIONS — Data should be obtained specific to any particular dredge of interest. Size, weight, configuration, etc. vary considerably according to each dredge even within one of the above categories. Physical specifications are likely to have a direct bearing on selecting an appropriate system for a spill situation since considerations usually involve temporary storage, transportation, treatment and disposal of dredged material. See also the separate entry Mudcat.

OPERATING SPECIFICATIONS — Principal advantages and disadvantages can be cited related to operational aspects of dredge types:

Mechanical Dredges: Clamshell, dipper and bucket dredges are designed for hard or soft materials and normally are not self-propelled crafts. No provision is made for material containment; thus, these units must work along-side the disposal area or be accompanied by disposal barges during the dredging operation. Principal advantages of mechanical dredges:

- the clamshell is capable of deep-water excavation;
- they can be controlled and manoeuvered in small and confined areas and would be useful in areas with obstructions and debris; and
- they excavate materials at nearly in-situ densities; thus, a smaller volume of dredged material must be handled and disposed of.

Principal disadvantages of mechanical dredges:

- they are capable of only modest production rate ($\leq$ 382 m^3/h (500 yd^3/h);
- they require separate disposal vessels and equipment;
- they cause a great deal of turbidity and sediment (contaminant) resuspension; and
- they would be ineffective against a free or unadsorbed liquid contaminant.

Hydraulic Dredges; Barge-Mounted Dredges - Barge-mounted types, such as the plain suction, dustpan and cutterhead dredges, will have difficulty in rough water (> 1m waves). Excessive vertical movement of the ladder can cause the head to be forced into or bounced off the bottom leading to excessive impact loads on the ladder, digging equipment, and transmission. Additionally, large differential movement between the barge and sections of the float-supported pipeline could result in undesirable stresses and failures in rigid pipe connections. Principal advantages of conventional barge-mounted hydraulic dredges:

- depending on size, they are capable of the highest production rates of any dredge (up to 11 468 m^3/h (15 000 yd^3/h); and
- pipeline directly to treatment/disposal area could minimize handling of and exposure to contaminated dredging material.

Principal disadvantages of conventional, barge-mounted hydraulic dredges:

- they cannot be employed in rough waters;
- the large volume of dredged material is 80 to 90% water, requiring major dewatering and consolidation operations for efficient disposal;
- anchoring cables and pipelines present temporary obstructions in navigable water channels; and
- cutterheads and suction lines are hindered and possibly damaged by underwater debris, large rocks, and other obstacles.

Hopper Dredges: The ocean-going hopper dredges are self-propelled vessels with self-contained storage of up to 6100 m^3 (8000 yd^3). Principal advantages of hopper dredges:

- self-contained storage of dredged material eliminates need for separate storage barge, scow, or pipeline. Some possess pump-out capability;
- hopper dredges can operate in rough, open waters and relatively strong current; and
- they operate without anchors and other restraints and can be used in shipping channels without causing excessive interference with normal traffic.

Principal disadvantages of hopper dredges:

- deep draft precludes use in shallow waters, including barge channels;
- they cannot work continuously, but must alternately load up, move to disposal site, dump or pump out, and return;
- to preclude overflow of hazardous materials, the full hopper capacity cannot be used;
- hopper dredges excavate with less precision than other dredge types; and
- open-water dumping cannot be used for contaminated material.

Pneumatic Dredges: Principal advantages of pneumatic dredges:

- they are crane-supported and thus can be operated in close and restricted areas and can be mounted on barges, seagoing vessels, as well as dockside;
- they can be operated in shallow or deep water with no theoretical maximum depth;
- they can be relatively easily dismantled and transported by truck or air;
- they may be able to yield denser slurries than conventional hydraulic dredges; and
- with passive excavating heads, they cause little turbidity of resuspension of solids.

Principal disadvantages of pneumatic dredges:

- they are capable of only modest production rates (up to 298 m^3/h (390 yd^3/h));
- cables and pipelines present temporary obstructions in navigable water channels;
- pneumatic systems are not in widespread use in the United States and, therefore, may not be as readily available as other types.

Special Purpose Dredges: See also separate entry this section - Mudcat.

Handheld Devices: A suction hose manipulated by a diver with pump and storage tank on board a barge, boat, or land-based truck could be invaluable in the precision dredging of intact masses of a solid or liquid contaminant. Practical use would be limited to very small spills or well-defined concentrations in difficult locations. Principal advantages of handheld suction devices:

- they are extremely mobile and universally available.
- with manual positioning, they are capable of surgical cleanup work.
- they would be particularly effective in vacuuming indentifiable masses of pure contaminant, particularly liquids and free-flowing solids.

Principal disadvantages of handheld suction devices:

- they are limited to very small quantities of material.
- they are ineffective against consolidated sediments.
- considerable volumes of water may be collected vis-a-vis the desired contaminant.
- clogging of the suction hose or small pump can often occur.

Operating characteristics for all dredges are summarized in the Table A:

STATUS OF DEVELOPMENT AND USAGE – Technologically-advanced dredging equipment is generally available in western Europe and Japan as compared with the more basic hardware in Canada and the United States. Although a wide variety of units are already in use world-wide, improvements continue to be made as concerns greater depth capability; greater precision, accuracy, and control over the dredging process; higher production efficiency; and decreased environmental degradation.

PERFORMANCE – An evaluation matrix was produced by T.D. Hand and A.W. Ford of the U.S. Army Corps of Engineers (see reference under Operating Specifications) for all spill sizes in ports and harbours. Spill response data are limited and were not taken from other sources. Note that a score of 0 is a poor rating while 10 denotes an excellent rating (Table B).

AVAILABILITY AND COMMERCIAL INFORMATION – In Canada and the United States, trades indexes such as Fraser's Canadian Trade Directory and the Thomas Register, or telephone directories, can be consulted for dredging companies and marine contractors in local areas. Many major urban centres are located on waterways so that such capability is widely available.

In the U.S., for example, the dredge fleet inventory has been summarized according to regional distribution:

U.S. Corps of Engineers

Location	Hopper	Sidecaster	Cutterhead	Dustpan	Clamshell	Dipper
West Coast	3	0	4	0	1	0
Gulf Coast	5	0	2	0	0	0
Interior Waterways	0	0	4	8	2	2
Great Lakes	4	0	1	0	0	0
East Coast	3	3	0	0	0	0
Total	15	3	11	8	3	2

U.S. Private Fleets

Location	Cutterhead	Clamshell	Dipper	Plain Suction	Hopper
West Coast	38	53	1	0	1*
Gulf Coast	75	23	0	0	0
Interior Waterways	31	33	5	19	0
Great Lakes	23	28	4	0	3*
East Coast	97	24	3	0	0
Total	264	161	13	19	4

* One on the West Coast and one on the Great Lakes are trailer hoppers and two on the Great Lakes are suction dredges mounted on hopper barges.

Source: CG-D-56-78

The following reference contains comprehensive summary information on dredging in the U.S.:

Murden, W.R. and Goodier, J.L., "The National Dredging Study", Dredging: Environmental Effects and Technology, Proceedings of WODCON VII, World Dredging Conference, San Pedro, CA (1976).

OTHER DATA – Major innovations in production dredging that might enhance hazardous material spills response include:

- ladder-mounted, submerged pumps for higher production at depths up to 60 m (197 ft);
- injection of buoyant material into pipe near dredging head (air and kerosene used to date) to provide increased lift and thus higher production and greater depth capability; similar in principle to airlift pumps;
- improved designs of dredging heads to minimize material resuspension;
- use of spud barges (aft of the dredge) to extend hull length and increase dredge swing; will increase production efficiency of cutterhead dredges; in limited use in the U.S. today;
- longer ladders, connected further aft on the dredge hull to increase depth and permit greater control;
- tandem pump systems for greater production efficiency and reliability;
- articulated ladder designs to maintain constant dredging head bottom contact; will allow use without damage in rougher waters;
- better hull designs, equipped with liquid stabilizing systems (swell compensators to allow use in heavier seas);
- improved production instrumentation to monitor flow rates, cumulative production, etc.;
- improved navigation, positioning, and bottom profiling instrumentation; state-of-the-art includes advanced laser, electronic, and acoustical systems;
- closed bucket modifications to reduce loss of fines and liquid in clamshell dredges;
- depth and swing indicators for mechanical dredges;
- clamshell to dipper convertible dredges; and
- use of silt curtains during dredging, as well as open-water disposal, to restrict turbidity plumes, and, in the case of hazardous materials, limit the added dispersion due to dredging. State-of-the-art is in U.S., but silt curtains are not in general use.

TABLE A SUMMARY OF DREDGE OPERATING CHARACTERISTICS

	Loss of Liquid	Percent Solids in Slurry by Weight(1)	Turbidity Caused	Operate in Open Water	Suitable For Liquid or Solid Retrieval	Vessel Draft (m)	Approx. Range of Production Rates (m^3/h)	Dredging Depths (m)		Maximum Wave Height (m)	Maximum Current	Lateral Dredging Accuracy(10) (m)
								Minimum	Maximum			
Mechanical												
Dipper	high	in-situ	high	yes(2)	solid	(3)	23-459	0(4)	15	< 1(7)	(9)	0.2
Clamshell or Grab	high	in-situ	high	yes(2)	solid	(3)	23-459	0(4)	46	< 1(7,8)	(9)	0.3
Hydraulic												
Suction	low	10-15%	low	yes(2)	both	1.5-1.8	19-7646	1.5-1.8	15-18	< 1	(9)	0.6-0.9
Dustpan	low	10-20%	avg.	no	both	1.5-4.3	19-7646	1.5-4.3	15-18	< 1	(9)	0.6-0.9
Cutterhead	low	10-20%	avg.	yes(2)	both	0.9-4.3	19-7646	0.9-4.3	4-20	< 1	(9)	0.6-0.9
Hopper	low	10-20%	avg.	yes	both	3.7-9.4	382-1529		20	< 2	(9)	3.1
Pneumatic												
Pneuma	low	up to 80% of in-situ	low	yes(2)	both	(3)	46-298	0(4)	46	< 1(7,8)	(9)	0.3
Special Purpose												
Mud Cat	low	10-40%	low	no	both	1/2	46-115	1/2	5	< 1/3	(9)	0.2
Handheld Vacuum	low	5-10%	low	yes	both	(3)	7.7	0(4)	31	(7)	(9)	0.2

(1) Percent solids could theoretically be 0, but these are normal working ranges. Percent solids = $\frac{\text{wt. of dry sediment}}{\text{wt. of wet slurry}}$

(2) Limited operation in open water possible, depending on hull size and type, and wave height.

(3) Depends on floating structure; if barge mounted, approximately 1.5-1.8 draft.

(4) Zero if used alongside of waterway; otherwise, draft of vessel will determine.

(5) Demonstrated depth; theoretically could be used much deeper.

(6) With submerged dredge pumps, dredging depths have been increased to 31 m or more.

(7) Depends on supporting vessel — usually barge mounted.

(8) Theoretically unaffected by wave height; digging equipment not rigid.

(9) Literature infers that water current hinders dredging operations but references avoid establishing maximum current limitations. For most dredges, limiting current is probably in the 3-5 knot range, with hopper dredges slightly greater, perhaps 7 knots.

(10) Vertical accuracies are generally within ± 0.3 m

References: Hand, T.D. and A.W. Ford, "The Feasibility of Dredging for Bottom Recovery of Spills of Dense, Hazardous Chemicals," proceedings of the 1978 U.S. National Conference on Control of Hazardous Materials Spills, Miami Beach, Florida (April 11-13, 1978).

TABLE B DREDGE EVALUATION MATRIX SPILL SCENARIO: PORTS AND HARBOURS - ALL SPILL SIZES

	Job Size Compatibility										Overall Potential			
	Small < 1000 yds^3	Medium 100 - 200 000 yds^3	Large >200 000 yds^3	Solids Content	Resuspension of Sediments and Contaminants	Dredging Depth Limitation	Vessel Draft Limitation	Debris and Structural Obstacles	Hinderance to Traffic	Transportation /Mobilization Time	Small Yardage	Medium Yardage	Large Yardage	Notes
WEIGHTING FACTOR	5	5	5	1	1	1	1	2	1	1	NA	NA	NA	NA
MECHANICAL														
Dipper	7	5	1	10	1	4	9	7	8	5	6.6	5.9	4.3	1,2,7
Clamshell	8	6	1	10	1	10	9	9	8	5	7.8	7.0	5.1	1,2,7
HYDRAULIC														
Cutter (and Plain Suction)	3	7	9	5	5	6	8	3	4	3	4.0	5.5	6.3	3,5,6
Dustpan	3	7	8	5	5	6	8	3	4	3	4.0	5.5	5.9	6
Hopper	3	7	7	5	5	6	5	1	9	4	3.9	5.5	5.5	6
PNEUMATIC	6	7	4	7	7	10	8	9	4	5	6.9	7.2	6.1	3,4,7
OTHER														
Mudcat	9	5	2	6	6	1	9	4	5	8	6.8	5.2	4.1	9
Handheld Vacuum	5	1	0	2	9	6	10	10	7	9	6.8	5.2	4.9	3,8

1. Can only be used for a solid contaminant unless it is known that a liquid contaminant is adsorbed in the sediment.
2. Pure mechanical devices will be relatively ineffective on hard rock or hardpan clay sediments.
3. Plain suction will be effective only in free flowing sediments such as sands, unconsolidated silty, clay, or organic sediments, and liquids.
4. Pneumatic systems which are normally operated in a plain suction mode could be operated with a variety of suction head devices such as augers and cutters.
5. Cutterheads should be turned off when operating in a rock or hardpan bottom to avoid unnecessary dispersion of contaminant and/or damage to dredging equipment.
6. Dredging depths can be effectively increased with the addition of auxiliary booster pumps at the suction head.
7. Equipment can be land-based and/or operated from the shore.
8. Handheld vacuum will seldom be suitable as a first line recovery device due to extremely limited production capacity. Probably will be most useful for precise cleanup and peripheral operations; in situations of small, concentrated well-defined spills; and for cleanup in close quarters.
9. Mudcat cannot be used in open water situations due to severe depth and wave height limitations but probably would be most effective in small, non-navigable streams.

(NOTE: THE NUMERICAL SCORES REFLECTED IN THIS TABLE SHOULD NOT BE CONSTRUED AS AN ABSOLUTE MEASURE OF THE DREDGE'S VALUE)

Other miscellaneous techniques of relevance include:

- The Amphidredge, manufactured by IHC-Holland, a major European dredge builder, is an amphibious, self-propelled vehicle that features backhoe and clamshell configurations as well as a shrouded cutterhead, similar to the Mudcat. The Amphidredge could prove to be a most useful and versatile device against spills in small, nonnavigable streams and marshy areas.

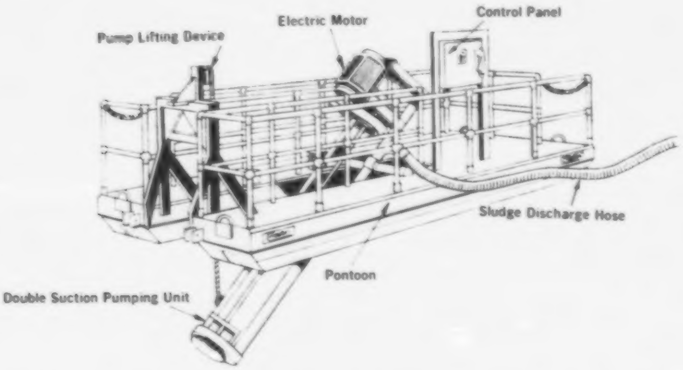
- A system has been developed by Takenaka Komuten Co., Ltd., of Osaka, Japan, for the dredging, treatment, chemical fixation, and land disposal of highly contaminated harbour sediments (organics, heavy metals). In this system, proprietarily named TST, a pneumatic Oozer dredge pumps the sediments to a sedimentation basin. The supernatant is charcoal-filtered and returned to the harbour while the sludge is mixed with a proprietary portland cement-based additive and pumped to a disposal site where it sets. The result is claimed to be a chemically-inert landfill with excellent stability and mechanical strength, capable of supporting heavy construction. This system could probably be made available in the U.S. given a sufficient lead time. Though it cannot be considered a response system, it does address all phases of the hazardous material cleanup problem.

- A special dredging head named Cleanup has been developed in Japan to be used with standard hydraulic suction dredges for cleaning up highly contaminated sediments with a minimum of turbidity and hazardous material resuspension and optimum dredging accuracy. It consists of an articulated box that completely encloses the suction head and allows water to be entrained and mixed from one direction only. It is highly instrumented in order to ensure a constant cutting depth and slurry density, and it features a trap to capture noxious gas bubbles that are released as the sediment is disturbed. Results of demonstrations have shown that turbidity and chemical oxygen demand (COD) in close proximity to the cleanup head are virtually the same as that of the undisturbed ambient water.

PRODUCT CRISAFULLI SLUDGE HANDLING SYSTEM **No. 55**

APPLICABILITY	Gas	Liquid			Solid		
		Sol	Fl	Sk	Sol	Fl	Sk
				*			*

DESCRIPTION – Barge-mounted solids handling pump for removing sludge.



OPERATING PRINCIPLE – The pump is mounted on a catamaran hull and, when in operation, is swung down between the hulls to the desired depth (the motor is located at the pivot point). Effluent is pumped to a separate storage container (no on-board storage).

PHYSICAL SPECIFICATIONS –

Length: 6.1 m (20 ft)
Width: 2.4 m (8 ft)
Height (overall): 1.7 m (5.6 ft)

Weight (approximately with 102 mm (4 in) electric motor): 2721 kg (5997 lb)
Floating Clearance: 203 to 254 mm (8 to 10 in)
Draft: 356 to 406 mm (14 to 16 in)
Aluminum Hand Rail
Flotation: Catamaran hulls of plate steel; foam-filled and epoxy coated.

Available with various pump types:

Model/Driving Motor	Standard Cleaning Depth (m)	Power (hp)	Pump Winch Operation
76 mm Electric	0.9 to 3.0	10	By Hand
102 mm Electric	0.9 to 3.0	25	By Hand
152 mm Electric	0.9 to 3.0	40	By Hand
76 mm Diesel-Hydraulic	0.9 to 3.0	12	Electric
102 mm Diesel-Hydraulic	0.9 to 3.0	26	Electric
152 mm Diesel-Hydraulic	0.9 to 3.0	54	Electric

Additional options available with increased cleaning depth.

OPERATING SPECIFICATIONS — Must be towed or moved by cables attached to shore.

Pump Size	Pump Flow (L/min)	Solids Moved Per Hour* (m^3)
76 mm	1893	34.4
102 mm	4353	78.7
152 mm	6624	119.3

* Based on an assumed 30% solids content in the fluid pumped, pump speed of 500 rpm and lift of 4.5 m (14.8 ft).

STATUS OF DEVELOPMENT AND USAGE — Commercial product used for sludge removal from lagoons located on industrial premises. Application to hazardous material spills has not been documented.

PERFORMANCE — No data were obtained.

AVAILABILITY AND COMMERCIAL INFORMATION —

Manufacturer:

Crisafulli Pump Company Inc.
Crisafulli Drive
P.O. Box 1051
Glendive, MO 59330
U.S.A.
Telephone (406) 365-3393
Contact: Mrs. M. Shipley

Distributor:

Charles R. Dow Equipment
P.O. Box 1777
Brantford, Ontario
Canada
N3T 5T9
Telephone (519) 752-3971

(Other Distributors in Calgary and Regina.)

OTHER DATA — None obtained.

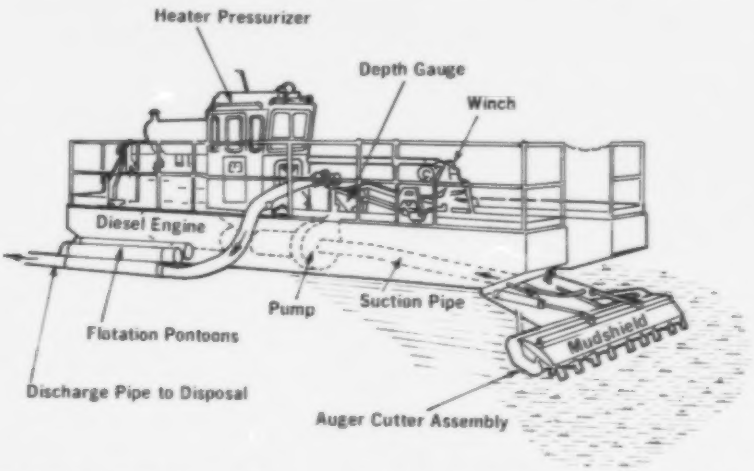
References: Manufacturers' Literature; personal communication, Mr. D. Seborg, Crisafulli Pump Co. Inc. (July 23, 1982).

PRODUCT MUDCAT AUGER DREDGING UNIT **No. 56**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
						*

DESCRIPTION – A recovery device used for the removal of solid/particulate hazardous materials deposited in water. Consists of a catamaran barge equipped with an underwater auger, mounted along the base of a bulldozer-type blade, and a diesel-driven pump. The unit is complete with pumps, winch, mudshield, hoses and offloading equipment. It is not self-propelled but is moved along on an anchored cable.



OPERATING PRINCIPLE – The auger-like cutting device is rotated so that bottom sediments are collected and fed via an elongated suction intake to a centrifugal pump. From there the dredged material enters a float-supported pipeline through which it is discharged for ultimate disposal ashore. The dredge mechanism is controlled by a hydraulic boom with the entire machine directed during each traverse of operation by being advanced along a steel cable.

PHYSICAL SPECIFICATIONS –

General:	Model SP 915	Model MC 915	Model SP 810
Length (m)	12.0	12.0	7.8
Width (m)	2.7	2.7	2.4
Height (m)	2.6	2.6	2.7
Weight (kg)	10 433.0	9 526.0	5 534.0
Draft (mm)	533.0	533.0	559.0
Floating Clearance (m)	2.1	2.1	—
Fuel Capacity (L)	1 363.0	1 363.0	379.0

Flotation:

* Model SP 915, MC 915:	Pontoons - Two 914 mm x 813 mm x 10.1 m, constructed of 10 gauge H.R. Steel with internal bulkheads and stiffeners; formed for rigidity; polyurethane foam filled.
* Model SP 810:	Pontoons - Two 762 mm x 813 mm x 6.9 m; constructed of 12 gauge steel with internal bulkheads and stiffeners; formed for rigidity; polyurethane foam filled.

Cutter Assembly:	Model SP 915	Model MC 915	Model SP 810
Auger:			
Diameter (mm)	346	346	229
Pitch (mm)	279	279	229
Flighting (mm)	9.5	9.5	9.5
Speed (rpm)	Up to 100	Up to 100	Up to 140
Cutter Knives (Heat-Treated)	45 Detachable Blades	45 Detachable Blades	46 Detachable Blades
Cutter Bars (Heat-Treated)	36 Detachable Blades	36 Detachable Blades	34 Detachable Blades
Auger Torque	1864 N-m	1864 N-m	452 N-m (nominal) 791 N-m (peak)

Mud Shield: (hydraulically adjustable)

- * Model SP 915, MC 915: 483 mm x 2.7 m (19 in x 9 ft)
- * Model SP 810: 356 mm x 2.4 m (14 in x 8 ft)

Pump: Centrifugal Recessed Impeller

	Model SP 915	Model MC 915	Model SP 810
Impeller Diameter (mm)	457	495	305
Suction Diameter (mm)	203	203	152
Discharge Diameter (mm)	152	152	152
Shaft Diameter (mm)	-	73	-

Electrical System:	Model SP 915	Model MC 915	Model SP 810
Voltage	12V	12V	12V
Alt. Output	65 Ampere	65 Ampere	42 Ampere
Batteries	12V, 205 Ampere Hour, Parallel-Wired		
Circuits	2-Wire System Full Ground		

Finish: Polyurethane finish coat on corrosion inhibitive epoxy primer.

OPERATING SPECIFICATIONS –

Working Capacity:	Model SP 915	Model MC 915	Model SP 810
Cut: Width (m)	2.7	2.7	2.4
Max. Depth (mm)	457	457	457
Operating Depth (max.-m)	4.6	4.6	3.0

Engine:	Model SP 915	Model MC 915	Model SP 810
	Detroit Diesel 6-71 RC 175 bhp @ 1 800 rpm	Detroit Diesel 6-71 RC 228 bhp @ 2 100 rpm	Detroit Diesel 4-53T Model 5043-8301 w/5A-60 Injectors 160 bhp @ 2 100 rpm

Drive:

- * Model MC 915: Clutch-Manual, 356 mm (14 in) diameter Disc and Pressure Plate Reduction-Gear Ratio 1.80/1 - Drive Coupling Flex Type
- * Model SP 810: Engine - Direct Hydraulic Dual Pump Drive

Pump:	Model SP 915	Model MC 915	Model SP 810
Capacity	126.0 L/s @ 1160 rpm against 36 m head	126.0 L/s @ 1160 rpm against 55 m head	76.0 L/s @ 1700 rpm against 35 m head

Model MC 915 can remove up to 92 m^3/h of material.

Service Water Pump (Model MC 915 only)

- Capacity: 4.7 L/s @ 2 800 rpm
- Pressure: 552 kPa

Propulsion: Treble Sheave Hydraulic Winch

	Model SP 915	Model MC 915	Model SP 810
Traverse Speed (m/min)	15.2	15.2	6.4
Average Cutting Speed (m/min)	2.4 to 3.7	2.4 to 3.7	2.4 to 3.7

Traverse speed shown is the maximum speed that can be achieved in a forward or reverse direction.

STATUS OF DEVELOPMENT AND USAGE – Commercially available product with documented usage on the removal of bottom sediments from lagoons and settling ponds.

PERFORMANCE – (Model SP 915 only)

- Removal of 5620 m^3 (198 000 ft^3) of sludge material in 49 hours from Crane and Company Paper Mills Effluent Lagoons.
- Removal of floating fibres and settled solids to a depth of 4.1 m at the settling pond at Western Kraft Corporation, Albany, OR.
- Removal of 4800 m^3 (170 000 ft^3) of solids in 48 hours and a total 5 070 000 L (1 340 000 U.S. gal) of reslurried settlings (consisting of latex particles, treated with alum and caustic) at the Dow Chemical Company pond in Dalton, Georgia.

Not documented for Model MC 915 and SP 810

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer: (Rental Available)

Mud Cat Division
National Car Rental Systems, Inc.
15670 West Ten Mile, Suite 107
Southfield, MI 48075
U.S.A.
Telephone (313) 557-4111
Contact: Mr. D. Tillotson
District Sales Manager

OTHER DATA – The Noyes Data Corporation publication "Hazardous Chemical Spill Cleanup" edited by J.S. Robinson (1979) summarizes the findings of a U.S. EPA study "Removal and Separation of Spilled Hazardous Materials from Impoundments" conducted by M.A. Nawrocki (EPA-600/2-76-245) and published in September 1976:

The Mudcat dredge was found to be "effective in removing undesirable particulate matter from pond bottoms. In the course of tests made during this study, two significant observations were made. First, the Mudcat was shown to have a greater efficiency in the removal of sediment during a backward cut than in a forward cut. The explanation given was that the mud shield was fully extended over the cutting auger in the backward direction and thus was more effective in decreasing the resuspension of any bottom sediments into the surrounding water column.

Secondly, the specific gravity of the spilled material had a definite effect on recovery efficiency. It was observed that as the specific gravity of the target material decreased, the material recovery rate decreased and resuspension of the spilled matter into the water body markedly increased. No reason was given for this phenomenon, but it is surmised that lighter material is more easily disturbed and, therefore, more readily resuspended. Principal advantages of the Mudcat:

- it is compact and readily transportable by truck or air;
- it can be operated in confined and isolated areas and in very shallow waters;
- it is compatible in production rate with an existing trailer-mounted treatment unit developed by the EPA;
- it would be readily available for lease from the National Car Rental Corporation and might be able to be activated on shorter notice than other dredges.

Principal disadvantage of the Mudcat:

- "its size and production capacity would limit it to small jobs."

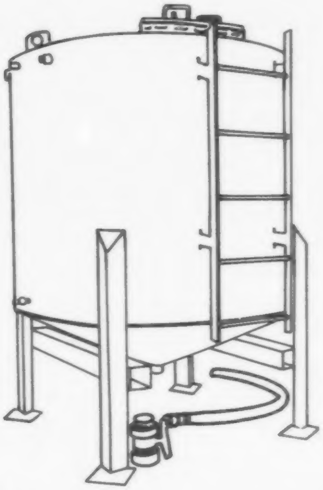
References: Manufacturer's Literature

PRODUCT ACTIVATED CARBON ADSORBER WATER PURIFICATION SYSTEM **No. 57**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – A packed bed of activated carbon for the removal of dissolved organics from groundwater, wastewater, or liquid process streams.



OPERATING PRINCIPLE – Contaminants are physically adsorbed from contaminated liquid flowing through the packed bed.

PHYSICAL SPECIFICATIONS – Pre-engineered systems available:

	760 L (200 U.S. gal)	3780 L (1000 U.S. gal)
Activated Carbon		
Required: kg (lb)	270 (600)	1360 (3000)
Diameter: m (ft)	1.22 (4)	1.68 (5.5)
Height: m (ft, in)	2.18 (7'2")	2.41 (7'11")

Material of Construction: Stainless Steel.
46 cm (18 in) manway.
Ladder mounted on side of vessel.
Carbon steel support frame.

Available Options:	Transfer pumps and controls. Air stripping and coalescing separation interface. Winterization (heat taping, insulation). Mild steel-lined.

OPERATING SPECIFICATIONS –

		760 L (200 U.S. gal)	3780 L (1000 U.S. gal)
Flow Rate:	L/min	38	189
	(U.S. gpm)	(10)	(50)
Operating Pressure:	kPa (abs)	103	103
	(psia)	(15)	(15)

Operating Modes: Packed Bed (downflow)
Backwash (downflow)
In series or parallel with other units
Capable of bulk carbon filling and removal.

STATUS OF DEVELOPMENT AND USAGE – This unit is commercially available. It was conceived for the removal of dissolved gasoline from groundwater and traces of PCBs, colours and odours from discharge waters.

PERFORMANCE – Typical activated carbon adsorption efficiencies:

Contaminant	Influent (ppb)	Effluent (ppb)
Benzene	20	ND
Toluene	51	ND
Xylene	12	ND
PCBs	530	ND

ND = Non detectable = < 1/2 ppb

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Oil Recovery Systems, Inc.
299 Second Avenue
Needham (Heights), MA 02194
U.S.A.
Telephone (617) 449-5222

OTHER DATA – This activated carbon adsorber can be interfaced with Oil Recovery Systems' Air Stripper (see Entry No. 60 of this survey) or coalescer to create a complete water purification system.

Reference: Oil Recovery Systems' "Technical Data Bulletin. Water Purification Systems: Activated Carbon Adsorbers" (1983).

CONCEPT ACTIVATED CARBON APPLICATION IN FLOWING STREAMS No. 58

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*	*		

DESCRIPTION – A concept to remove hazardous materials spills from flowing streams using activated carbon. Buoyant carbon may be deployed directly or, alternatively, a sinking carbon may be used in a porous fabric bag.

OPERATING PRINCIPLE – Buoyant activated carbon is applied directly to the stream where natural turbulence causes contact between the carbon and the material to be adsorbed. The carbon is captured downstream by a boom and pumped as a slurry to a storage tank.

The sinking carbon is enclosed in a porous fabric bag ("tea bag") and dropped into the contaminated stream. The bag permits the contaminated water to flow in, but is of a sufficiently small mesh to contain the carbon.

Removal efficiency is highly dependent upon flow patterns and weather conditions (factors affecting turbulence and contact of the carbon with the spill plume). It also depends on how soon following the spill the carbon is applied.

PHYSICAL SPECIFICATIONS –

The following data describe the materials used during Battelle-Northwest tests performed for the U.S. Environmental Protection Agency:

Floating Carbon Technique:	12 x 40 mesh Nuchar 190 activated carbon (manufactured by Westvaco, Covington, VA)
Carbon "Tea Bag" Technique:	12 x 40 mesh Filtrasorb (manufactured by Calgon, Pittsburgh, PA) packaged in strips of four 58 cm^2 (9 in^2) pockets of a polyester monofilament screen cloth (manufactured by Kressilk Products Inc.). Space is provided in each pocket to allow for enhanced fluidization of the carbon.

OPERATING SPECIFICATIONS – Floating carbon can be dispersed on the surface of the spill plume, pumped beneath the spill surface as a slurry or released from ballasted containers from the bottom of the stream. Containers considered for the latter method have been weighted plastic bottles, unfired clay containers, and an ice matrix incorporated with gravel.

Carbon "tea bags" have been attached to floats and allowed to contact the surface of the spill plume. (Weighting "tea bags" to the bottom of a contaminated stream was not investigated during the Battelle-Northwest study).

A steam stripper has proved useful for regenerating carbon "tea bags" contaminated with hexone.

STATUS OF DEVELOPMENT AND USAGE – Adsorbing hazardous materials from flowing streams has been investigated by the U.S. EPA throughout the 1970's. The technique has been tested on controlled test spills of an organophosphate pesticide and hexone. Use of the technique on an actual spill situation has not been documented.

PERFORMANCE – Approximately 80% of 35 kg (78 lb) of an emulsifiable oil solution of an organophosphate pesticide was removed from the water of a test stream through the use of 380 kg (835 lb) of activiated carbon released by plastic bottles from the bottom of the stream.

Hexone (methylisobutyl ketone) was removed from a test stream with approximately 50% efficiency using floating carbon in a weight ratio of 10:1 with hexone. Removal efficiency was approximately 20% using floating carbon tea bags. A general observation was that wind blew floating carbon away from the plume of a spill rendering the carbon ineffective.

AVAILABILITY AND COMMERCIAL INFORMATION – More detailed information regarding in-situ application of activated carbon to spills in waterways is available through the report:

Dawson, G.W., B.W. Mercer and R.G. Parkhurst, Battelle-Northwest, Richland, WA 99352, In-Situ Treatment of Hazardous Material Spills in Flowing Streams, U.S. Environmental Protection Agency, Report No. EPA-600/2-77-164 (NTIS No. PB 274 455) (October, 1977).

U.S. EPA contact: Ira Wilder
Joseph P. Lafornara
Oil and Hazardous Materials Spills Branch
Industrial Environmental Research Laboratory-ci
Edison, NJ 08817
Telephone (201) 321-6632

OTHER DATA – An October 1981 report completed by Rockwell International concluded through mathematical modeling of phenol spills that free floating carbon treatment was more effective than buoyant packets ("tea bags") or panels floating normal to the direction of the waterway.

Reference: George R. Schneider, Rockwell International, Removal of Water Soluble Hazardous Materials Spills from Waterways by Activated Carbon, U.S. Environmental Protection Agency, Report No. EPA-600/S2-81-195 (NTIS no. PB 82-103 813) (October, 1981).

Also see "System for Application of Slurried Carbon to Surface Waters" (Entry No. 64).

Direct application of activated carbon to a spill in an agitated stationary body of water has been proven successful by the Zimpro P.A.C.T. process described in Section 5.3 of this survey.

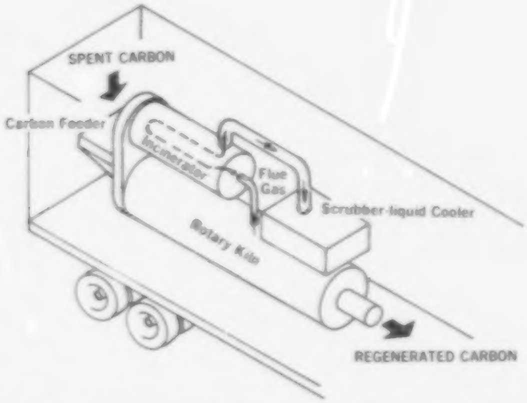
PRODUCT ACTIVATED CARBON REGENERATOR **No. 59**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
				•	•	•

Note: This unit regenerates solid granular carbon.

DESCRIPTION – Prototype. A self-contained, trailer-mounted unit used to regenerate carbon which has adsorbed chemicals during a spill cleanup. The unit consists of equipment to dry and regenerate the carbon as well as to exhaust gases.



OPERATING PRINCIPLE – Spent carbon is drained of excess water and fed to the kiln. The carbon is regenerated as it progresses through the direct-fired rotating kiln barrel. The regenerated carbon is screened before reuse. Flue and adsorbate gases are ducted to a direct-fired incinerator. The exhaust from the incinerator is then scrubbed prior to release to the atmosphere. Spent process water is filtered and carbon treated prior to discharge.

PHYSICAL SPECIFICATIONS –

Transport Vehicle

Closed: 2.4 x 13.7 x 4.1 m (8 x 45 x 13 ft) wide x long x high
Open: 6.4 x 16.2 x 6.4 (21 x 53 x 21) wide x long x high
Capacity Payload: 27 210 kg (59 987 lb)

Kiln

Rotating, direct-fired (propane)
Insulation: B&W kaowool; alumina-silica ceramic fiber
Liners: Hot Corrosive Sections: Inconel-601
"Milder" Conditions: Stainless Steel (316 L/304 L) (83.5 U.S. gal/ 80 U.S. gal)
Barrel: 371 mm (14.5 in.) I.D. x 3.9 m (13 ft) long sloped at 21 mm/m

Feed Hopper: 0.6 m^3

Incinerator: Propane fired
Firebox: 0.6 x 0.6 x 1.5 m (2 x 2 x 5 ft) wide x high x long

Scrubber: Spray tower: 406 mm dia. x 1.8 m high, (16 in x 6 ft) Inconel-625
Sump: 380 L (100 U.S. gal); 316 L (83.5 U.S. gal) stainless steel

Generator: Katolight Diesel-Electric generator 74 KVA-240V-3PH (may also be operated on local supply when available)

OPERATING SPECIFICATIONS –

45 kg (100 lb) dry/h of 40 mesh or larger granular carbon.
Approximately 20 minutes residence time at about 1000°C (1800°F).
75% of carbon's original adsorptive capacity is restored with approximately 80% bulk recovery of the carbon.

STATUS OF DEVELOPMENT AND USAGE – Prototype. The mobile carbon regeneration unit was scheduled to undergo initial shakedown and preliminary testing in 1982. No documented results of this testing were available in June 1984.

PERFORMANCE – Laboratory-scale tests performed for the EPA resulted in adsorptive recovery rates for four representative chemicals as follows:

Chemical	Adsorptive Capacity Recovered
Dichloromethane	99%
Diethyleneglycodiethylether	87%
Benzenesulfonic Acid	100%
Tris (2-monochloroethyl) phosphate	100%

A pilot run using spent carbon from a spill cleanup in Plains, VA, indicated satisfactory regeneration. Pollutants included toxaphene (most prevalent) adrin, dieldrin, heptachlor and chlordane.

AVAILABILITY AND COMMERCIAL INFORMATION – The mobile carbon regenerating unit was developed for:

Municipal Environmental Research Laboratory-Ci
U.S. Environmental Protection Agency
Edison, NJ 08817
U.S.A.
Telephone (201) 321-6634
Contact: Dr. J.E. Brugger

by: MSA Research Corporation
Evans City, PA 16033
U.S.A.
Telephone (412) 538-3510
Contact: Mr. Gunther H. Griwatz

OTHER DATA – None obtained.

References: Juhola, A.J. and J.E. Brugger, MSA Research Corporation: "Pilot Study of Activated Carbon Regeneration", Proc. 1976 Nat. Conf. on Control of Hazardous Materials Spills, pp. 219 - 224 (1976).

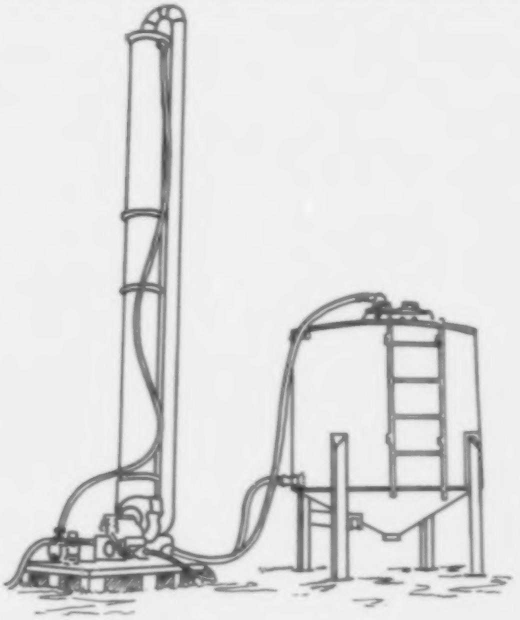
Griwatz, G.H. and J.E. Brugger, MSA Research Corporation: "Activated Carbon Regeneration" Mobile Field-Use System, Proc. 1978 of Nat. Conf. on Control of Hazardous Materials Spills, pp. 350 - 355 (1978).

PRODUCT AIR STRIPPING WATER PURIFICATION SYSTEM **No. 60**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*			*		

DESCRIPTION – The system consists of a vertical packed column with an air blower, motor, and controls for stripping petroleum hydrocarbons and chlorinated solvents from groundwater.



OPERATING PRINCIPLE – Contaminated groundwater is cascaded down through the packed column countercurrent to a high flow of air from the blower at the bottom. Efficiency of the system depends on packing type and height, tower diameter, and a correct air-to-water ratio.

PHYSICAL SPECIFICATIONS – ("pre-engineered" units)

Size	Flow Rate	Blower Rating
0.6 x 3.7 m (2 x 12 ft)	94.6 to 454 L/min (25 to 120 U.S. gpm)	0.47 m^3/s (1 000 cfm)
0.9 x 4.3 m (3 x 14 ft)	379 to 1060 L/min (100 to 280 U.S. gpm)	1.89 m^3/s (4 000 cfm)
1.2 x 4.3 m (4 x 14 ft)	946 to 1893 L/min (250 to 500 U.S. gpm)	4.72 m^3/s (10 000 cfm)
1.8 x 6.1 m (6 x 20 ft)	1703 to 3785 L/min (450 to 1000 U.S. gpm)	9.44 m^3/s (20 000 cfm)

Material of Construction: corrosion-resistant FRP (Fiberglass Re-inforced Plastic)
High-low water probes
Mist eliminator
Available Options: - Automatic controls
- Stainless steel construction
- Winterization (heat tape, insulation)

OPERATING SPECIFICATIONS –

Water and air flow are independently adjustable.
Gravity output (optional pumped discharge).
Continuous operation.
Maximum water flow is 3785 L/min (1000 U.S. gpm).

STATUS OF DEVELOPMENT AND USAGE – Commercially available. In general use in the petrochemical industry.

PERFORMANCE – Typical air stripping system efficiencies:

Contaminant	Influent (ppb)	Effluent (ppb)	Removal (%)
Gasoline Benzene	385	16	96
Toluene	1800	75	96
Xylene	260	11	96
Trichloroethylene	650	6.3	>96
1,2 Dichloroethylene	1200	7.4	>96
See also Other Data			

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Oil Recovery Systems, Inc.
299 Second Avenue
Needham (Heights), MA 02194
U.S.A.
Telephone (617) 449-5222
Contact: Mr. Andrew Segal

OTHER DATA – This air stripping system can be interfaced with Oil Recovery Systems' Activated Carbon Adsorber (see Entry No. 57) or coalescer to create a complete water purification system.

Oil Recovery Systems, Inc. is capable of feasibility studies to size a system by running samples through a lab-scale stripper or an on-site pilot unit.

* Key parameters to the effective use of this system include air and water temperature; highly volatile compounds with low solubility in water are most easily stripped. Higher-than-optimum water levels depress contaminant removal while too much air may cause channelling and increase costs.

Reference: Recovery Systems Inc., "Technical Data Bulletin, Water Purification Systems: Air Stripping" (1983).

CONCEPT APPARATUS FOR CHEMICAL DECONTAMINATION OF WATER No. 61

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*		*		

DESCRIPTION – Concept. An apparatus for chemical decontamination of groundwater contaminated with organic materials. Apparatus can be fixed in place or be mobile and operate continuously or intermittently.

OPERATING PRINCIPLE – The apparatus withdraws groundwater for treatment with at least one strong oxidizing agent and/or bactericide; degasses the water; and recharges it to the withdrawal site.

PHYSICAL SPECIFICATIONS – Not obtained.

OPERATING SPECIFICATIONS – The waste water is treated with ozone or chlorine gas. Can treat water contaminated with aliphatic or aromatic hydrocarbons, pesticides, herbicides, fungicides and phosphorus compounds. The treated water can be recharged to the land by sprinkling; and/or feeding the aqueous mixture to and/or into the earth strata.

STATUS OF DEVELOPMENT AND USAGE – Patented concept. No indication obtained of development beyond a preliminary evaluation phase; usage on spills of hazardous material spills not documented.

PERFORMANCE – Testing was conducted on treating three wells with this apparatus; the results were:

	Case 1: Well "S" Before Treatment	After Treatment
Average Withdrawl	60 m^3/h (water)	60 m^3/h (water)
Average Number of Bacteria	240/mL	2/mL
Average Bacteria Growth	38/100 mL	14/100 mL

For Well "S", 10 m^3/h of water withdrawn charged with 0.6 g/m^3 of ozone, degassed and returned to site.

	Case 2: Well "E" Before Treatment	After Treatment
Oxygen Concentration	1.9 g/m^3	5.1 g/m^3
Degree of Saturation	18.2%	50.9%

Well had water supplying capacity of 72 m^3/h, about 10% was withdrawn, charged with 0.2 to 0.3 g/m^3 of ozone, and returned to earth source; treatment was continued for 4 months for "After Treatment" values.

	Case 3: Well "O" Before Treatment	After Treatment
Concentration of hydrocarbons in the water bearing ground layer	170 g/ton of the earth region	3.5 g/ton of the earth region

For Well "O", 12 m^3/h water was charged with 0.8 g/m^3 of ozone for 3 months.

AVAILABILITY AND COMMERCIAL INFORMATION – Aquatechnique Sierre S.A., Chippis, Switzerland

OTHER DATA – This apparatus is the patented invention of E. Forte and H. Schulthess of Sierre Switzerland, and is assigned to the Aquatechnique Sierre S.A. Note that long-term treatment of several months duration is required for the successful application of this approach.

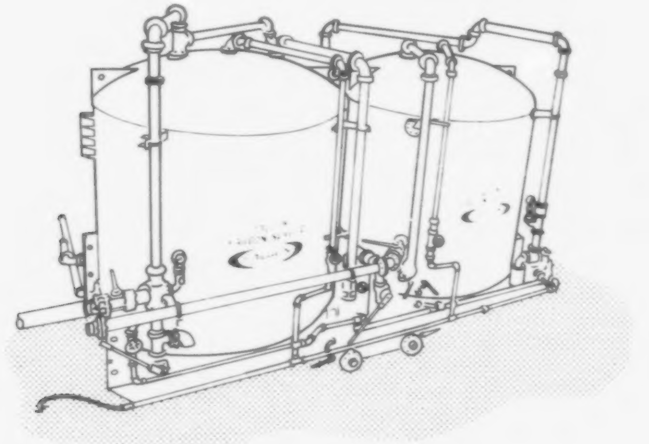
Reference: U.S. Patent 4 167 973

PRODUCT CALGON MOBILE WATER TREATMENT UNIT **No. 62**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – A trailer-mounted carbon adsorption system for removal of dissolved organic wastes from water at spill sites or industrial lagoons.



OPERATING PRINCIPLE – Once influent piping and pumping are installed, the wastewater is passed through beds of activated carbon which adsorb dissolved organics. Effluent lines carry the treated water to the desired point of discharge. Exhausted carbon can be replenished with fresh carbon delivery by special Calgon trucks.

PHYSICAL SPECIFICATIONS –

System consists of single or multiple pre-piped adsorber vessels.
Adsorber vessel contains approximately 10 tons of granular activated carbon.
Two grades of granular activated carbon available: Filtrasorb 300 and 400.
Filtrasorb 300 and 400 packaged in: 4-ply polyethylene reinforced kraft bags, 27 kg (60 lb), 1-ton bulk packs, or bulk shipped by rail or truck.

OPERATING SPECIFICATIONS – Organics that are removed from water by the Filtrasorb carbon units are:

- organic chemicals that are adsorbed well, i.e., dyes, phenolics, pesticides and PCBs;
- general classes of aromatics, esters, ethers and ketones; and
- non-polar compounds with more than four carbon atoms.

Used in the removal of organically complexed heavy metals in an effluent lagoon. Removes refactory organic chemicals not responsive to biological treatment.

Removal of organic compounds in high or low concentrations.

Used in emptying lagoons to avoid overflows, seepage into groundwater or poisoning of biological treatment systems.

Filtrasorb 300 and 400:

Carbon has a total surface area of approximately 950 to 1050 m^2/g
Volume and settled bulk density of Filtrasorb in system utilizing backwash procedures:
Filtrasorb 300: 416 to 432 kg/m^{-3}
Filtrasorb 400: 400 to 416 kg/m^{-3}

Filtrasorb specifications:

	Filtrasorb 300	Filtrasorb 400
Iodine Number (min)	900	1000
Abrasion Number (min)	75	75
Moisture (max)	2.0%	2.0%
Mean Particle Diameter (mm)	1.5 to 1.7	0.9 to 1.1
Effective Size (mm)	0.8 to 0.9	0.55 to 0.65
Water Soluble Ash (max)	0.5%	0.5%
U.S. Standard Series Sieve Size:		
Larger than No. 8 (max)	15%	–
Smaller than No. 30 (max)	4%	–
Larger than No. 12 (max)	–	5%
Smaller than No. 40 (max)	–	4%

STATUS OF DEVELOPMENT AND USAGE – Calgon Mobile Treatment Units are available on a lease basis through a 24-hour emergency phone number (412) 777-8000 for response to organic chemical spills.

PERFORMANCE – Calgon's Mobile Treatment System was used to treat groundwater contaminated with methylene chloride and 1,1,1-trichloroethane at the site of a truck accident near Sault Ste. Marie, Michigan, U.S.A., in the Winter of 1980. Groundwater collecting in a shallow lagoon fed by 20 interceptor trenches around the spill site was pumped at 38 L/min (10 U.S. gpm) through the adsorbers on a continuous, 24 h/day basis. After one month of operation, the system achieved less than 1 ppb of each of the spilled chemicals in the treated effluent, well within government standards of 2.0 ppb for methyl chloride and 5.3 ppm for 1,1,1-trichloroethane. Proper cleanup of the site was necessary to prevent contamination of a nearby creek which feeds the St. Mary's River and which flows in turn into Lake Superior.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Calgon Environmental Systems Division
Calgon Corporation
Box 1346
Pittsburgh, PA 15230
U.S.A.
Telephone (412) 923-2345

Distributor:

Calgon Canada
27 Finley Rd.
Bramalea, Ontario
Canada
L6T 1B2
Telephone (416) 457-5310

Other offices in Montreal, Regina, Edmonton and Vancouver.

OTHER DATA – Calgon dispatches its mobile units from Pittsburgh or Houston with personnel to supervise connection and start-up and perform laboratory analyses in trailered facilities.

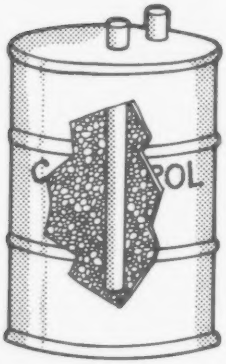
Consult trade journals such as Thomcat (U.S.A.) or Fraser's (Canada) for suppliers of activated carbon.

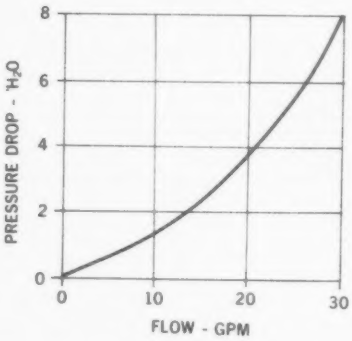
PRODUCT CARBTROL ADSORPTION CANISTERS No. 63

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
*	*	*	*			

DESCRIPTION – Carbtrol adsorption canisters are pre-engineered activated carbon columns for treating low flows of liquids. (Similar canisters are available for treating vent gases. See "OTHER DATA".)





OPERATING PRINCIPLE – Liquids contaminated with organics are percolated up through activated carbon contained in an appropriately designed steel drum.

PHYSICAL SPECIFICATIONS –

Canisters: Epoxy-lined carbon steel drums fitted with chemically inert internal distribution and collection systems.

Model L-1:	Diameter cm (in)	61 (24)
	Height cm (in)	86 (34)
	Shipping Weight kg (lb)	109 (240)
	Media Volume L (ft^3)	218 (7.7)
	Inlet (top) mm (in)	25 (1)
	Outlet (top) mm (in)	25 (1)

Activated Carbon: 68 to 91 kg (150 to 200 lb) of custom selected activated carbon for the specific organics to be treated.

OPERATING SPECIFICATIONS –

Capacity: up to 1.6 L/s (25 U.S. gpm)
Operating Temperature: up to 93°C (200°F)
Operating Pressure: up to 101.3 kPa gauge (15 psig)
Exhausted canisters can be transported "as is" (U.S. D.O.T. approved container for hazardous waste) to a chemical landfill or incinerator for disposal.

STATUS OF DEVELOPMENT AND USAGE – Commercially available for removal of organics from surface and groundwater; wastewater treatment; and product purification. Typical contaminants removed by the Carbtrol Adsorption Canisters include:

Hydrocarbons
Solvents
Amines
Aldehydes
PCBs
Pesticides

PERFORMANCE – Not documented for use in response to hazardous material spills.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

IPC Systems, Inc.
39 Riverside Avenue
Westport, CT 06880
U.S.A.
Telephone (203) 226-5642

OTHER DATA – Similar Carbtrol canisters are available for low flows (up to 28 m^3/min (1000 CFM)) of storage tank vent gases, reactor exhausts, fume hood exhausts, etc. (Model G-1 is $475 U.S. F.O.B. Westport, CT, December 1983). Calgon also markets VENTSORB canisters for industrial air purification applications. For more information contact:

Calgon Corporation
Activated Carbon Division
Calgon Center
Box 1346
Pittsburg, PA 15230
U.S.A.
Telephone (412) 777-8000

In Canada: Calgon Canada
27 Finley Road
Bramalea, Ontario
L6T 1B2
Telephone (416) 457-5310

Reference: Manufacturer's Literature

PRODUCT DEMCO HYDROCYCLONES **No. 64**

APPLICABILITY	Gas	Liquid			Solid		
		Sol	Fl	Sk	Sol	Fl	Sk
							*

DESCRIPTION – A venturi effect is created within a cone to remove particulate matter from a fluid stream.

OPERATING PRINCIPLE – Suspended solids are separated from the fluid by centrifugal force caused by rotation of the fluid in the cone assembly; heavier particles settle to the bottom of the cone while the lighter, clarified effluent moves toward the centre vortex where it escapes through an overflow outlet.

PHYSICAL SPECIFICATIONS –

Materials:
Liners, O-rings, seal, ball valve (portion): Buna N
Ball Valve: Bronze
Silt Pot Body: Steel
Inlet, Vortex Finder, Cone for Silt Pot: Ductile Iron
All other components are stainless steel

Dimensions: Cone:
Height = 522 mm (20.5 in)
Maximum Width (includes inlet) = 225 mm (9 in)
Weight = 22.7 kg (50 lb)
Silt Pot: Height = 552 mm (20.5 in)

OPERATING SPECIFICATIONS – Optimum pressure range corresponds to a flow rate of 26.5 to 34 L/s (7 to 9 U.S. gal).

STATUS OF DEVELOPMENT AND USAGE – Commercial product designed for separation of particulates from liquids. Usage on hazardous material spills not documented.

PERFORMANCE – Tests on simulated hazardous materials performed for the U.S. EPA gave the following removal efficiencies:

Material	% Removal
Iron Powder	42.9
Glass Beads	87.8
Iron Filings	83.8
Coal	55.2

The hydrocyclones were part of a complete system including a Mudcat dredge.
Testing was conducted on latex and proved unsuccessful. It was concluded that hydrocyclones would only be appropriate for removal of contaminants held on particles of sand size (74 µm) or larger.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Demco Incorporated
845 S.E. 29th Street
P.O. Box 94700
Oklahoma City, OK 73143
U.S.A.
Telephone (405) 631-1321

Distributor:

Demco Incorporated
9835-42 Avenue
Edmonton, Alberta
Canada
T6E 5M7
Telephone (403) 463-3313

OTHER DATA – Units available in other sizes. Specifications provided only for those items used in EPA tests. The venturi effect of the hydrocyclone is unlikely to produce a pronounced separation of liquid contaminants from water particularly for those substances with a specific gravity approximating 1.

References: L.B. Soisberg, A Catalogue of Oil Skimmers, Report EPS 3-EP-83-1, Environment Canada, Ottawa, Ontario, September, 1983, pp. 34-39 (Cyclonet 050, 100 and S).

Nawrocki, M.A., Removal and Separation of Spilled Hazardous Materials from Impoundment Bottoms, Hittman Associates Limited, Report EPA-600/2-76-245 (September, 1976).

PROTOTYPE SYSTEM FOR APPLICATION OF SLURRIED CARBON TO SURFACE WATERS **No. 65**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*				

Note: Liquids which sink in water could be treated in-situ by activated carbon if sufficient turbulence and mixing are provided.

DESCRIPTION – Prototype system utilizing a slurried buoyant activated carbon for application into a contaminated, static body of water; components include pumps, jet-slurrier surge tank, carbon bins.

OPERATING PRINCIPLE – Water is pumped into a jet-slurrier where the carbon and water are mixed. The slurry enters a surge tank for flow equalization and is pumped into the contaminated water. Spent carbon is retrieved with an oil boom.

PHYSICAL SPECIFICATIONS –

Carbon Hopper/Tote Bin

Dimensions: 1100 x 1200 x 2100 mm (42 x 48 x 83 in) wide x deep x high
Construction: Aluminum
Certified watertight
Capacity: 2040 L (539 U.S. gal)
Valve: Butterfly, butyl rubber, remote operation
"Tote Systems Incorporated"

Jet-Slurrier - "Haliburton" - 150 mm (6 in) diameter connection to tote bin

Pumps - High Pressure Water Feed: Marlow 63 mm (2.5 in) fire pump. Slurry Pump: Hydromatic 76 mm (3 in) self-priming trash pump

Surge Tank - Dimensions: 3 x 3 x 3 m (9.8 x 9.8 x 9.8 ft). Capacity 758 L (200 U.S. gal)

OPERATING SPECIFICATIONS – Not documented.

STATUS OF DEVELOPMENT AND USAGE – A prototype has been developed and tested for the U.S. EPA.

PERFORMANCE – Testing completed for the U.S. EPA indicated a 98% recovery of Diazinon.

AVAILABILITY AND COMMERCIAL INFORMATION –

Contractor:

Battelle Pacific Northwest Laboratories
Richland, WA 99352
U.S.A.
Contact: Mr. G.W. Dawson
Mr. J.A. McNeese
Mr. J.A. Coates

Sponsoring Agency:

Industrial Environmental Research Laboratory
Office of Research and Development
U.S. EPA
Cincinnati, OH 45268
U.S.A.
Contact: Mr. J.P. Lafornara, U.S. EPA
Edison, NJ 08817

OTHER DATA – See "Application of Activated Carbon in Flowing Streams" (Entry No. 58).

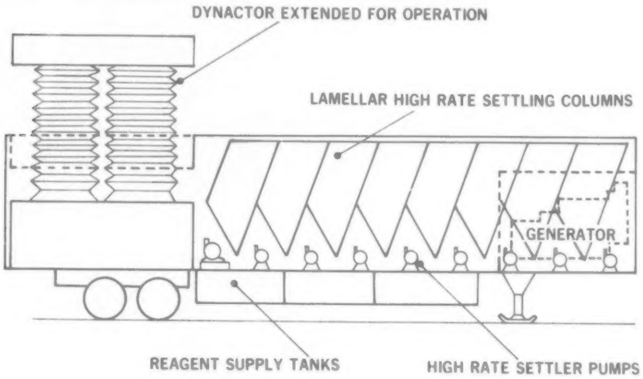
Reference: Dawson, G.W., J.A. McNeese, and J.A. Coates, Battelle Pacific Northwest Labs: Application of Buoyant Mass Transfer Media to Hazardous Material Spills, EPA 600/2-80-078 (May, 1980).

PROTOTYPE DYNACTOR **No. 66**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – A self-contained, self-powered trailer equipped with a dynactor (reaction vessel), process pumps, reagent storage, reagent feed equipment (liquid or powder), settling system and chemical analysis bench for treating contaminated waters at a spill site.


DYNACTOR EXTENDED FOR OPERATION
LAMELLAR HIGH RATE SETTLING COLUMNS
GENERATOR
REAGENT SUPPLY TANKS
HIGH RATE SETTLER PUMPS

OPERATING PRINCIPLE – Primarily a spray tower where contaminated water is atomized at the top of a column and intimately contacted with a treating agent (liquid or solid). Chemical equilibrium is reached as the mixture falls into a holding reservoir, from which the contaminant and treated water are separated through a series of settlers.

PHYSICAL SPECIFICATIONS –

Trailer:

Length: 13.7 m (45 ft)
Height (in operation): 7.9 m (26 ft)

Reservoir: Aluminum construction coated with coal tar epoxy.
Reaction Column and Return Duct: Fiberglass-reinforced neoprene rubber.
Dynactor nozzle fed by stainless steel tubing.

Generator:

125 kVA; diesel-electric
Fuel tanks contain enough fuel for 48 hours operation.

Pumps:

Low pressure submersible for lowering into the spill itself; portable; 5 hp
Dynactor motive pump; 1379 kPa nozzle pressure "Fire Engine Pumper" pump; 50 hp; 15.8 L/s.

Chemical Feed:

Power Feed: Consists of hopper, auger and fluidizing system.
Liquid Feed: Variable speed chemical pump to deliver reagents to the suction side of the Dynactor pump.

Settlers: 10 high rate lamellar settling columns; 762 mm (30 in) square; 3.7 m (12 ft) high; stainless steel; each column has separate 1.6 L/s centrifugal pump.

Chemical Bench: Equipped with equipment appropriate to the spill.

OPERATING SPECIFICATIONS – The Dynactor System has been designed to process up to 15.8 L/s of contaminated liquid.

STATUS OF DEVELOPMENT AND USAGE – The Dynactor System was used to remove and detoxify creosote deposits from the bed of the Little Menomee River in Wisconsin under EPA Contract 68-03-0181.

PERFORMANCE – Tests at laboratory scale performed for the U.S. EPA found the Dynactor could successfully detoxify waters contaminated with the following:

Acids
Bases
Phenol
Aliphatic and Aromatic Hydrocarbons, Chlorine
Cyclic and Acrylic Pesticides

Decontamination was achieved by one or more of the following processes:

Oxidation
Neutralization
Precipitation
Adsorption on Activated Carbon
(A magnetic separator was necessary to separate precipitates and flocculated carbon.)

AVAILABILITY AND COMMERCIAL INFORMATION – The Dynactor was engineered and constructed for:

Municipal Environmental Research Laboratory
U.S. Environmental Protection Agency
Edison, NJ 08817
U.S.A.
Telephone (201) 321-6635
Contact: Mr. I. Wilder

OTHER DATA – The system is under evaluation by U.S. EPA for application to gaseous materials.

References: Sanders, R.G., Rich, S.R. and Pantazelos, T.G., Industrial Bio-Test Laboratories, Inc. and R.P. Industries, Inc.: Feasibility of 5 GPM Dynactor/Magnetic Separator System to Treat Spilled Hazardous Materials, (April, 1975).

Sanders, R.G., Rich, S.R. and Pantazelos, T.G., Industrial Bio. Test Laboratories, Inc. and R.P. Industries Inc.: "A Mobile Physical-Chemical Treatment System for Hazardous Material Contaminated Waters" Proc. 1976 Nat. conf. on Control of Hazardous Materials Spills, pp. 412 - 415 (1976).

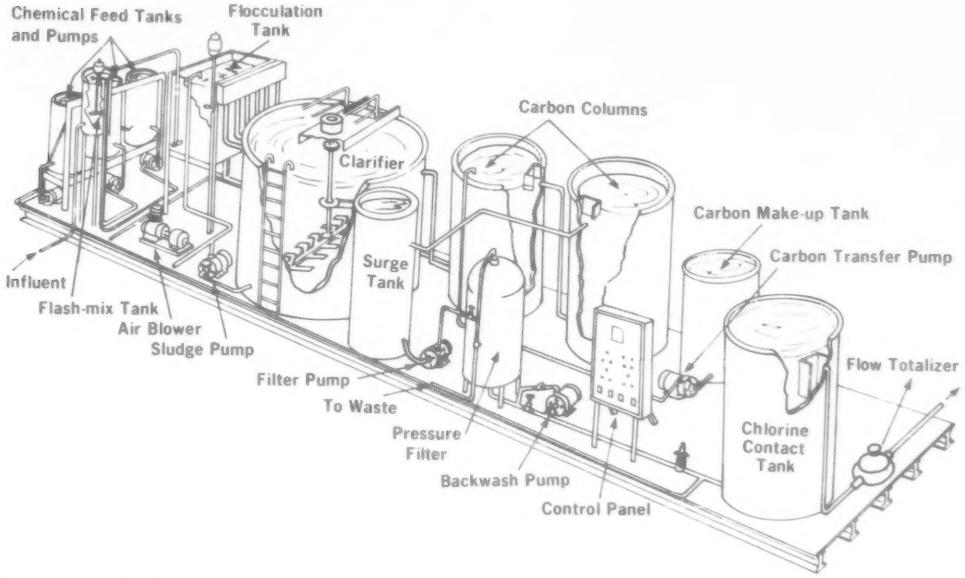
PRODUCT EPA/MET-PRO INDEPENDENT PHYSICAL/CHEMICAL WASTEWATER TREATMENT SYSTEM **No. 67**

APPLICABILITY

Gas	Liquid Sol	Liquid Fl	Liquid Sk	Solid Sol	Solid Fl	Solid Sk
	*	*	*	*	*	*

Wastewaters containing liquid and suspended solid contaminants.

DESCRIPTION – A mobile wastewater treatment process comprised of skid-mounted pumps, piping and vessels for long-term treatment of wastewater through neutralization, flocculation, sedimentation, carbon adsorption, filtration and disinfection.



OPERATING PRINCIPLE – Coagulant and other chemicals are added to the influent through a flash-mix tank. Solids separation follows in a flocculation tank and clarifier. Dissolved organics are then removed in two activated carbon columns; the effluent produced is finally polished in a pressure filter and disinfected in a chlorine tank.

PHYSICAL SPECIFICATIONS – Model 12050 has been modified by the U.S. EPA to enhance its mobility and provide for a variety of treatment flow patterns for testing purposes (Beechgrove Demonstration Project).

Skids		
Shipping Data	Flocculation-Clarifier	Adsorber-Filter
Length m (ft)	4.6 (15)	7.5 (24.75)
Width m (ft)	3.0 (10)	3.0 (10)
Height m (ft)	3.1 (10.1)	2.7 (8.75)
Weight:		
Dry kg (lb)	5 500 (12 000)	7 800 (17 000)
Operating kg (lb)	24 000 (53 000)	20 000 (45 000)

Skids constructed of 152 mm (6 in) weld-fused 23 kg/m (15.5 lb/ft) I beams and 4.8 mm (3/16 in) plate.

Pumps and Blowers

Sludge Pump: Moyno 1L4CDQ; 1 hp electric motor; 2.2 L/s (35 U.S. gpm) @ 69 kPa gauge (10 psig)

Lime Slurry Feeder: Wallace and Tiernam metering pump, series 44, model 44-313; up to 79 L/h (20.8 U.S. gph)

Acid Feed Pump: Precision Control Products Model 9721-21; 1/4 hp electric motor; 1.9 to 19 L/h (0.5 to 5 U.S. gph)

Backwash Pumps:

- for Downflow Carbon Column: Ingersol Rand Model 1-1/2 x 1-1/4 x 3 hp; up to 7.9 L/s @ 15.2 TDH (125 U.S. gpm @ 50 ft TDH)
- for Pressure Filter: same as above; up to 5 L/s @ 24.4 m TDH (80 U.S. gpm @ 80 ft TDH).
- Booster Pumps: Ingersol Rand Model 1-1/4 x 3/4; 1-1/2 hp; good for 2.2 L/s @ 24.4 m TDH (35 U.S. gpm @ 80 ft)

Pressure Filter Pump: same as Booster Pump
Aeration Blower: Gast Model 1022; 3/4 hp

Tankage

Unit	Diameter mm (in)	Height mm (in)	Volume L (U.S.G)	Residence Time (min)
Flash Mix	508 (20)	1219 (48)	246 (65)	1.9
Flocculation	1219 x 1219 sq (48 x 48)	1448 (57)	2157 (570)	16.2
Clarifier	3048 (120)	2438 (96)	17827 (4 710)	135
Acid Mix	559 (22)	914 (36)	284 (75)	2.2
Upflow Adsorber	1219 (48)	2438 (96)	2861 (756)	21.6
Downflow Adsorber	1219 (48)	2438 (96)	2861 (756)	21.6
Pressure Filter	914 (36)	1524 (60)	a	a
Surge Tank	914 (36)	2438 (96)	1605 (424)	12
Chlorine Contact	1524 (60)	2438 (96)	4459 (1178)	33.6
Chemical Feed	610 (24)	1219 (48)	356 (94)	b
Lime Slurry	1219 (48)	1219 (48)	1363 (360)	b

"a" denotes 3.36 L/m^2s (4.95 U.S. gpm/ft^2)
"b" denotes 1 1/2 days storage - usually

Piping, Fittings

PVC Schedule 40 where socket-welded and Schedule 80 where threaded. Air lines are black steel Schedule 40 with malleable iron fittings, 68 kg (150 pound) rating.

Flanges and/or unions are provided at terminal points for easy hookup of field connections.

Unions and/or flanges are positioned at the suction and discharge of pumps, motorized valves, and other devices that may need to be removed from the line for maintenance or replacement so that the minimum of work will be necessary.

Pipelines that carry raw sewage or sludge are provided with a number of plugged clean out ports in strategic positions.

Lime slurry lines are flexible hose with Evertite quick disconnects for rapid clean out as per Met-Pro standard lime slurry feeding system.

Overflow points are provided on the plant in case of system backup in strategic locations.

Block Valves

Valves are gate or ball bronze body in non-corrosive areas and PVC ball valve in corrosive areas. Valves are positioned at a tank where flooding could result if piping were detached for any reason. Gravity flow lines do not include valves.

Valves are positioned on suction and discharge of pumps where flooding could be caused due to removal of pumps from the line.

Control Valves

Sludge diverter valve - QC1-L (or equal) 3-way rotor valve, full port, ball valve with Ramcon 25 BR actuator. Valve bronze with Teflon seats.

Air diverter valve - QC1-L 1.9 cm (3/4 in) NPT 3-way rotor valve reduced port with Ramcon 8BR actuator, 115/1/60 bronze body with Teflon seats.

Dole valve (or Griswold) 40 GH good for 151 L/min (40 GPM) for adsorber flow and pressure filter flow.

Griswold flow control valve, Model 12 (PVC construction screwed ends) flow control valve good for 43 L/min (125 GPM) flow, 5.1 cm (2 in) pipe size for adsorber backwash.

Griswold flow control valve, Model 12 PVC construction, 5.1 cm (2 in) screwed connections. Flow 265 L/min (70 GPM) for pressure filter backwash.

Carbon Transfer System

Met-Pro standard carbon transfer system, complete with eductor, flexible hose, quick disconnects, fluidizing water control and related accessories. Transfer to be at a rate not to exceed 8.1 kg (18 pounds) (dry basis) per minute of carbon in a slurry of 0.9 kg/3.8 L (2 lb/gal) of water.

Controls and Instruments

Westinghouse Components:

Selector switch with legend plate, motor starters with thermal overload, circuit breakers, transformers 240/120 VAC, terminal blocks as per National Electric Code.

Timers:

Automatic Timing and Controls, Inc. - backwash and sludge recycle.

Paragon - 24-hour time clock for programmed backwash of up to 8 backwashes per day.

pH Analyzer/Controller - Leeds & Northrup pH receiver, range 2-12 pH complete two (2) alarms (high and low) SPST contacts rated at 120 volts AC 5 amps (from stock).

pH Mounting and Electrode - automatic temperature compensated.

Cable - six conductor, 3 m (10 ft).

Agitators:

Flash mix agitator - Lightnin Model NC-4, 1/4 hp, 240/3/60 TE, 1750 rpm.

Flocculation agitator - Lightnin Model NP-2AVM, 240/single phase/60 TE, 3/4 hp, 1750 rpm input, 20 to 350 rpm output.

Lime feed agitator - Lightnin Model ND-2 with 1/2 hp, 1750 rpm, 240/3/60 motor TE.

Acid mix agitator - Lightnin Model NC-4, 1/4 hp, 240/3/60 TE motor, 1750 rpm.

Acid feed tank agitator - Neptune B1.0, 115/1/60 TE, 1750 rpm.

Sludge rake drive - Winsmith 5MCVTW, 1/4 hp, 240/3/60 TE, 3 rpm.

Also required:

1 800 kg (4 000 lb) Gravel
300 kg (700 lb) Sand
270 kg (600 lb) Anthracite
1 200 kg (2 600 lb) Activated Carbon

Sodium Hydroxide
Ferric Sulphate
Calcium Hypochlorite

OPERATING SPECIFICATIONS – An additional equalization tank ahead of the influent pump may be required to minimize flow fluctuations of the incoming wastewater. All operations, except the addition of chemicals and treating agents, are automatically controlled so that an operator is required for chemical makeup, sludge disposal and general mechanical maintenance.

Design Capacity: 189 m^3/day (50 000 U.S. g/day) of Model 12050.

Other Met-Pro IPC units are available:

Unit Capacity m^3/day	(U.S. g/day)	Space Req'd m^2	(ft^2)	No. of Skids	Total Power Req'd (hp)	Shipping Weight kg	(lb)
19	(5 000)	11.1	(120)	1	8		5 000
38	(10 000)	13.0	(140)	1	9		5 500
57	(15 000)	13.0	(140)	1	10		6 400
95	(25 000)	19.0	(205)	1	14		8 640
136	(35 000)	19.5	(210)	1	15		9 100
190	(50 000)	32.5	(350)	2	19		10 500
280	(75 000)	38.5	(415)	2	25		12 300
380	(100 000)	53.9	(580)	4	28		16 800
570	(150 000)	67.4	(725)	4	36		21 400
1 100	(300 000)	134.7	(1 450)	8	62		38 200

STATUS OF DEVELOPMENT AND USAGE – Commercially available from Met-Pro for small communities, recreational areas, schools, industry, construction sites, pilot plants - where very long-term wastewater treatment is required. A study (Beechgrove Demonstration Project) is being conducted (1984) by the U.S. Environmental Protection Agency using the Met-Pro Model IPC 12050.

PERFORMANCE – Performance data pertaining to the Beechgrove Demonstration Project could not be obtained.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Met-Pro Corporation
Systems Division
167 Cassell, Box 144
Harleysville, PA 19438
U.S.A.
Telephone (215) 723-6751

Modification and testing of the Model 12050 are being performed by the Environmental Emergency Response Unit of the U.S. EPA.

For further information on EERU activities and capabilities, contact:

James J. Yezzi, Jr.
Oil and Hazardous Materials Spills Branch
Municipal Environmental Research Laboratory
U.S. Environmental Protection Agency
Edison, NJ 08837
U.S.A.
Telephone (201) 321-6703

or

J. Stephen Dorrler, Chief
Environmental Response Team
U.S. Environmental Protection Agency
Edison, NJ 08837
U.S.A.
Telephone (201) 321-6740

OTHER DATA – Other products of Met-Pro, Systems Division include:

Factory Water Treatment Plants (Bulletin 2000)
Gravity and Pressure Filters (Bulletin 6000)
Carbon Adsorption Columns (Bulletin 10 000)

PROTOTYPE EPA MOBILE FLOCCULATION-SEDIMENTATION SYSTEM **No. 68**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*	*	*	*

Wastewaters containing liquid and suspended solid contaminants.

DESCRIPTION – Prototype; trailer-mounted physical-chemical treatment system for flocculation, sedimentation, and filtration of suspended solids for pretreating wastewater contaminated with hazardous materials.

OPERATING PRINCIPLE – Chemicals, including powdered carbon, aluminum salts, lime, iron salts, polyelectrolytes, acids and bases, can be introduced at various points into a long, looped pipe reactor. Static mixers in the reactor provide rapid and effective mixing. Effluent from the reactor is gently agitated in flocculation chambers, the floc collecting in a tube settler and discharged to a sludge collector. The wastewater finally passes through a tri-media filter. Further treatment is then required to remove the hazardous materials.

PHYSICAL SPECIFICATIONS –

System enclosed in a 12.2 m (40 ft) long van-type trailer.
Pipe reactor measure 170 m (560 ft) in length.

OPERATING SPECIFICATIONS – Design flow rate of 265 L/min (70 U.S. GPM) for effective solids removal.

STATUS OF DEVELOPMENT AND USAGE – A full-scale field demonstration pilot plant has been developed for the U.S. EPA and evaluated in a number of field tests.

PERFORMANCE – "The system was shown to be highly effective for treating.... (combined sewage and raw municipal) wastewater. Subsequent controlled field studies demonstrated that the flocculation/sedimentation system is highly effective for pretreating wastewater that is contaminated with hazardous materials. Additional information on the system is contained in the EPA report, EPA-R2-73-149."

AVAILABILITY AND COMMERCIAL INFORMATION – The mobile flocculation-sedimentation system is operated by the U.S. Environmental Protection Agency's Environmental Emergency Response Unit (EERU). Private contractors may use this and other EERU equipment for research or emergency spill response.

For further information on EERU activities and capabilities, contact:

James J. Yezzi, Jr.
Oil and Hazardous Materials Spills Branch
Municipal Environmental Research Laboratory
U.S. Environmental Protection Agency
Edison, NJ 08837
U.S.A.
Telephone (201) 321-6703

or

J. Stephen Dorrler, Chief
Environmental Response Team
U.S. Environmental Protection Agency
Edison, NJ 08837
U.S.A.
Telephone (201) 321-6740

OTHER DATA – No other information obtained.

Reference: Environmental Emergency Response Unit (ERRU) Capability, A booklet released by the Oil and Hazardous Materials Spills Branch, Municipal Environmental Research Laboratory-Ci, U.S. Environmental Protection Agency, Edison, NJ 08837 (April, 1982).

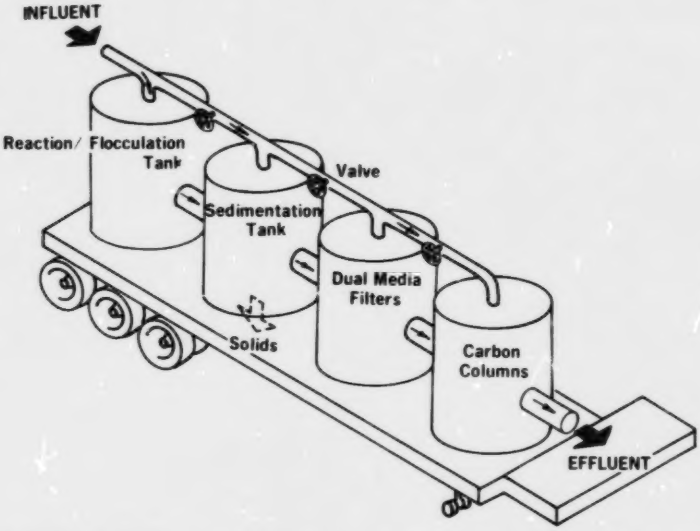
PROTOTYPE EPA MOBILE PHYSICAL/CHEMICAL TREATMENT TRAILERS No. 69

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*	*	*	*

Wastewaters containing liquid and suspended solid contaminants.

DESCRIPTION – Two trailer-mounted systems for treating water contaminated with hazardous materials, consisting of tanks for flocculation/sedimentation, filtration and carbon adsorption.



OPERATING PRINCIPLE – Contaminated water is pumped into a settling tank where flocculation and sedimentation occur. The clarified liquid is drawn off and is then passed through mixed media filters and finally through carbon adsorption columns. Sludge is removed from the sedimentation tank and stored for ultimate disposal.

Since each step can be by-passed, treatment schemes may be varied to facilitate the recovery of spilled materials.

PHYSICAL SPECIFICATIONS – Two trailers are available:

One is a 13.7 m (45 ft) trailer with three mixed media filters, three pressure carbon columns, pumps, piping and a 100 kW diesel generator. A support trailer has additional pumps, fittings and several collapsible rubber tanks. The treatment trailer can be located up to 150 m (492 ft) from the spill site.

The second unit is mounted on a smaller trailer and is towed by a stake truck which also carries the additional equipment, such as collapsible tanks and gasoline engine pumps. The treatment trailer has one mixed media filter and one pressure carbon column.

Equipment constructed of 316 stainless steel.
Reaction/flocculation tank of 11 350 L (3000 U.S. gal).
Sedimentation tank of 56 775 L (15 000 U.S. gal).
Reaction/flocculation and sedimentation tanks are of collapsible rubber construction.

Dual Media Filters:

61 cm (24 in) anthracite coal, 0.9 mm (0.035 in) effective diameter (upper layer), 1.7 uniformity coefficient.
45 cm (18 in) fine sand (0.45 mm (0.018 in) effective diameter), 1.5 uniformity coefficient
Diameter 1.17 m
Area 0.893 m^3 (31.5 ft^3)
Backwash water storage tank of 11 350 L (3000 U.S. gal)

Carbon Columns:

May be used in parallel or series.
Total carbon (dry) 19.6 m^3 (692 ft^3); 8172 kg (18 000 lb)
Diameter: 2.1 m (7 ft)

OPERATING SPECIFICATIONS –

Large unit can treat 6.3 to 37.8 L/s (100 to 600 U.S. gpm)
Smaller unit can treat 1.8 L/s (30 U.S. gpm)

Site requirements:

Area 15 x 30 m (49 x 98 ft)
Ideal slope for site 5 cm over 8 m (2 in over 26 ft)
Maximum slope for site 15 cm over 8 m (6 in over 26 ft)

STATUS OF DEVELOPMENT AND USAGE – The Mobile Physical-Chemical treatment trailers have been used extensively by the EPA's Environmental Emergency Response Unit, including the following incidents:

Removal of the pesticide dinitro-butyl-phenol (DNBP) from a small lake in Clarksburg, New Jersey during August 1979. Contents of the lake were recirculated until the DNBP concentration had been reduced from 8 ppb to less than 2 ppb.

The contaminated water was put through the mixed media filters, then through three carbon columns run in series.

Decontamination of the contents of a chemical waste lagoon in Oswego, New York during March 1977. The following removal efficiencies were obtained in the secondary and tertiary lagoons.

Compound	Influent Conc. (μg/L)	Effluent Conc. (μg/L)	(%) Removal
Trichloroethylene	21	0.3	98.57
Phenol	140	0.1	99.92+
Cresol	230	8.1	96.47
Dimethylphenol	1220	5.4	99.56
Trimethylphenol	130	10	92.3
Butylphenol	300	15	95
Diocyladipate	360	320	11
Dimethylaniline	380	23	93.95
Methylene Chloride	190	51	73.15
Carbon Tetrachloride	1.1	0.1	90.91+
Benzene	1	0.1	90
Toluene	120	0.3	99.75
Xylenes	140	0.1	99.92+
Trichloroethane	12	0.1	99.17+

Contents of the main lagoon were treated using pH adjustment, flocculation/sedimentation, mixed media filtration and carbon adsorption. The treated water was released to Wine Creek when its TOC was reduced by 75% (initial concentration: 6500 to 15 000 mg/L) and no PCBs were detected (original concentration approximately 0.075 μg/L).

Decontamination of ground and surface waters in a Haverford, PA incident, November-December 1976.

Water in the area, both the stream (Naylors Run) and groundwater, were contaminated with an oil (similar to diesel fuel) and pentachlorophenol (PCP).

The entire process of settling tanks and filters was used. The oil was reduced from 5 to 10% to 30 to 50 mg/L and the PCP from 100 to 500 mg/L to 30 to 20 mg/L after two stages of settling. Following treatement in the filters, the final effluent had no detectable oil (less than 1.0 mg/L) and the PCP concentration was consistently less than 1 µg/L. Total volume treated was 764 570 L (202 000 U.S. gal).

Treatment of a watercourse containing oil and mixed chemicals at Dittmer, MS (April and May, 1977).

Following sand filtration and carbon adsorption the PCB (Aroclor 1260) concentration dropped from about 19 µg/mL to less than 0.05 to 0.2 µg/mL.

PERFORMANCE – Bench-scale tests performed in the development of the prototype gave these results:

Activated carbon may be used for treatment of acetone, cyanohydrin, acrylonitrile, chlorine and phenol.

Chlorination can be used for the oxidation of ammonia and 50% removal of acetone, cyanohydrin, and acrylonitrile.

Most pesticides and herbicides (chlorinated hydrocarbons) can be removed by coagulation, filtration and carbon adsorption.

Tetraethyl lead and tetramethyl lead can be effectively oxidized with potassium permanganate and can also be absorbed partially via activated carbon after chemical flocculation, settling and filtration.

AVAILABILITY AND COMMERCIAL INFORMATION – The mobile Physical/Chemical Treatment trailers are operated by the U.S. Environmental Protection Agency's Environmental Emergency Response Unit (EERU). Private contractors may use this and other EERU equipment for research or emergency spill response.

For further information on EERU activities capabilities, contact:

James J. Yezzi, Jr.
Oil and Hazardous Materials Spills Branch
Municipal Environmental Research Laboratory
U.S. Environmental Protection Agency
Edison, NJ 08837
U.S.A.
Telephone (201) 321-6703

or

J. Stephen Dorrler, Chief
Environmental Response Team
U.S. Environmental Protection Agency
Edison, NJ 08837
U.S.A.
Telephone (201) 321-6740

OTHER DATA – None obtained.

References: Lafornara, J.P., M. Polito and R. Scholz, U.S. EPA and Envirex "Removal of Spilled Herbicide from a New Jersey Lake", Proc. 1976 Nat. Con. on Control of Hazardous Materials Spills, pp. 378-381 (1976).

Lafornara, J.P., F.J. Freestone and M. Polito, U.S. EPA, "Spill Cleanup at a Defunct Industrial Waste Disposal Site", Proc. 1978 Nat. Con. on Control of Hazardous Materials Spills, pp. 152-155 (1978).

Lamp'l, H.J., T. Massey and F.J. Freestone, U.S. EPA, "Assessment and Control of a Ground and Surface Water Contamination Incident, Haverford, Pennsylvania, November-December 1976, Proc. 1978 Nat. Con. on Control of Hazardous Materials Spills, pp. 145-147 (1976).

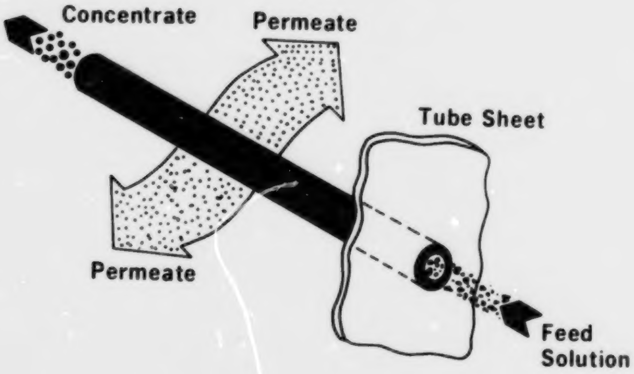
Gilmer, H. and F.J. Freestone, U.S. EPA, "Cleanup of an Oil and Mixed Chemical Spill at Dittmer, Missouri, April-May 1977", Proc. 1978 National Conference on Hazardous Materials Spills, pp. 131-134 (1978).

Mahendra K.G., Envirex Inc. for the U.S. EPA; Development of a Mobile Treatment System for Handling Spilled Hazardous Materials, Report EPA-600/2-76-109 (July, 1976).

PRODUCT HOLLOW FIBER ULTRAFILTRATION (UF) SYSTEM **No. 70**

APPLICABILITY	Gas	Liquid			Solid		
		Sol	Fl	Sk	Sol	Fl	Sk
		*	*	*	*	*	*

DESCRIPTION – Portable systems capable of purifying contaminated (oil-like) water by filtration. The systems consist of hollow fibre cartridges, permeate storage tank, circulation and backwash pumps. They have been designed for waste treatment in metal working, plating, chemical process and general industrial applications.



OPERATING PRINCIPLE – The process solution is pumped under pressure through the inside or lumen of the fibres. The membrane fibres are anisotropic with a skin on the inside surface and a sponge-like structure on the outside. Separation occurs at the liquid/membrane interface with rejected solutes and particles remaining inside the skin. The flow along the hollow fibres can be controlled to produce high shear forces to break away rejected species and force them downstream. The ultrafiltrate which permeates through the hollow fibres is collected in a plastic sleeve and then ducted into a permeate storage tank. Cleaning of the cartridges is accomplished by forward flushing, recycling, backflushing or by a combination of these methods.

PHYSICAL SPECIFICATIONS – (Romicon® HF1S Pilot Plant System - see also Other Data) Wetted materials (process) are made of stainless steel.

Dimensions:

Height 1702 mm (67 in)
Width 1118 mm (44 in)
Depth 813 mm (32 in)

Circulation Pump Ladish C114-4
Circulation Pump Motor 2hp, 3500 rpm, TEFC
Backwash Pump Corcoran 2000 E
Backwash Pump Motor 3/4 hp, 3500 rpm, TEFC

Electrical Requirements:

230 V-30-60 Hz: 6.8 A
460 V-30-60 Hz: 3.4 A

Hollow fibre ultrafiltration cartridges:

Cartridge diameter 76.5 mm (3 in)
Cartridge length 635 mm (25 in) and 1092 mm (43 in)
Contain 45 to 3000 hollow fibre membranes
Membrane inside diameters 0.51 mm (0.02 in) to 1.1 mm (0.04 in)
Active membrane surface area of 0.1 to 4.9 m^2 (1.1 to 53 ft^2) per cartridge

OPERATING SPECIFICATIONS – (Romicon HF1S Pilot Plant System - manufacturer's data)

Operating pressure 172 kPa
Recirculation rate 2.2 L/s
Operating temperatures 49°C

Hollow fibre ultrafiltration cartridges: Designed for initial distilled water flux ranges from 85 to over 350 $L/m^2/h$; maximum temperature ranging from 45°C to 75°C over a pH range of 1.5 to 13.0

STATUS OF DEVELOPMENT AND USAGE – Commercial products in general use as waste treatment systems in a variety of chemical process industries.

PERFORMANCE – Not documented for spills of hazardous materials.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer: Romicon, Inc.

Subsidiary of Rohm and Haas Company
100 Cummings Park
Woburn, MA 01801
U.S.A.
Telephone (617) 935-7840
Telex: 94-9333
Contact: Mr. Barry Green

OTHER DATA – Other Romicon UF systems are available with higher processing capacities:

System	Capacity m^3/day	U.S. gal/day
CPVC-2	2.8 - 5.6	750 - 1500 (skid-mounted)
HF-6	8.5 - 17	2250 - 4500
HF-20	28.4 - 56.7	7500 - 15 000
HF-50	70.9 - 141.9	18 750 - 37 500

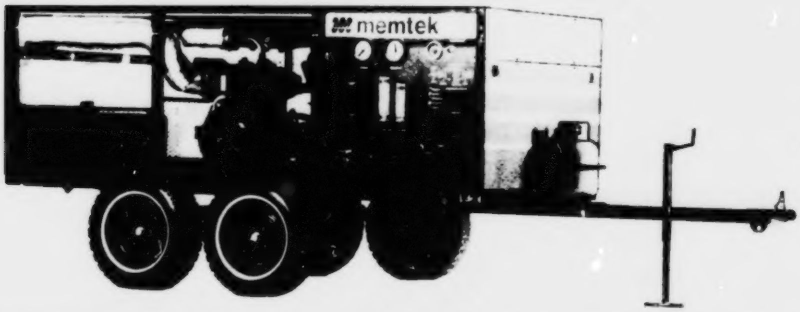
Various Romicon fibre membranes are available:
XM-50 for low temperatures
PM or MH series for higher temperatures

PRODUCT MOBILE ULTRAFILTRATION REVERSE OSMOSIS UNIT **No. 71**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*	*	*	*

DESCRIPTION – A trailer-mounted, helicopter-portable Reverse Osmosis (RO)/Ultrafiltration (UF) unit for treating water contaminated with hazardous materials. The self-contained, diesel-powered unit, developed for the Environmental Protection Service of Environment Canada, can produce up to 1800 L/h of pure water (permeate) from salt water. It was developed for the cleanup of chemical spills and the production of fresh water for steam cleanup of oil on low energy rocky shorelines.



OPERATING PRINCIPLE – UF is employed when filtering fine, suspended solids (down to 0.002 µm) or oils. RO separates both suspended and dissolved solids plus BOD and COD by permeating pure water through semi-permeable membranes. The concentrate of chemicals is stored for other methods of ultimate disposal. The permeate is returned to its original, uncontaminated source.

PHYSICAL SPECIFICATIONS – The system consists of two banks of three pressure vessels, each containing up to two RO or UF membranes. The unit is complete with filters, feed pump and self-contained diesel power source. The unit contains fuel for 8 hours of continuous operation and has a built-in propane heater to prevent freeze-up during cold weather operations.

Pumps are constructed of stainless steel and marine brass. Hydraulic hosing is used for piping.

Dimensions: 431.8 (127 for hitch) x 182.8 x 137.1 cm (45.7 grd. clearance) 170 (50 for hitch) x 72 x 54 in (18 grd. clearance) (length x width x height)
Weight: 1270 kg (2800 lb)
Operating Environment: -28 to 38°C (-20 to 100°F)

OPERATING SPECIFICATIONS – Water Production:

RO: 56.7 m^3 (15 000 U.S. gal)/day from sea water
113.5 m^3 (30 000 U.S. gal)/day from brackish water

UF: 284.0 m^3 (75 000 U.S. gal)/day from contaminated water

Lift/feed Pump: 380 L/min (100 U.S. GPM) @ 96.5 kPa (14 psig) from a depth of 10 m

Two parallel high-pressure pumps raise feed pressure to 2750 to 6900 kPa (400 to 1000 psig) for RO. Membranes may be of spiral wound, tubular or hollow fibre construction. During unattended operation, the unit will automatically shut down if:

1) Normal operating pressure or temperature is not maintained.
2) Blocked inlet occurs.
3) Membrane ruptures (only inorganic salts detected by conductivity sensor in permeate stream).

Designed for most organic and inorganic liquids in the pH range of 2 to 11.

STATUS OF DEVELOPMENT AND USAGE – An operational prototype was originally fabricated. It has been used to clean up a spill of sodium penta- and tetrachlorophenol. Further investigation of long-term operational capability, membrane materials and trials on other substances (e.g., chemical leachate) are being conducted. Additional UF/RO units are also now being constructed.

PERFORMANCE – Test results have demonstrated the following:

UF - Removal of trace suspended oil (5 to 500 ppm)
- Dewatering drilling mud
- Blue-green algae removal from pond water

RO - EPS field trials conducted at the Gloucester Chemical disposal landfill site near Ottawa, Ontario, Canada, yielded the following results from four different membranes:

MEAN ORGANIC ANALYSIS OF REVERSE OSMOSIS
SAMPLES FROM GLOUCESTER LANDFILL (WELL 36W) OTTAWA, CANADA

Chemical	Feed Concentration (ppb)	% Concentrated in Concentrate*	% Removed by each Membrane			
			Toray	DSI	UOP	Filmtec
Dichloromethane	408	168	60	60	-5	2
Acetone	105	217	85	82	31	43
Dichloroethene	36	340	98	96	76	86
Tetrahydrofuran	18260	173	98	93	62	76
Diethyl Ether	211	335	97	94	75	81
Chloroform	270	268	96	90	73	65
Dichloroethane	99	232	100	87	37	49
Trichloroethane	676	324	92	98	91	97
Trichloroethene	23	207	96	90	35	47
Benzene	576	265	98	94	53	77
Bromoform	10	342	100	99	97	98
Hexane	10	398	100	99	95	99

* Recirculation increased chemical in concentrate beyond original percentage in feed stream.

(Note: The feed solution was filtered through one of two banks of 10-25 µm filters to reduce fouling of the RO membranes by suspended solids.)

Manufacturer	Membrane*	Membrane Material
Toray	PEC 1000	TFC Polyether-Polysulphone
UOP	TCF 4600	TFC Polyether-amide-Polysulphone
Film Tec.	FT30	TFC Polyamide/Polysulphone
Desalination Inc.	B441	TFC Polyamide
		* TFC is thin film composite.

* All membranes have a spiral wound configuration.

AVAILABILITY AND COMMERCIAL INFORMATION – The prototype unit was modified from a mobile water purification unit manufactured by:

Memtek Corporation
87 Bentley Avenue
Nepean, Ontario
K2C 6T7
Telephone (613) 226-8381
Contact: Peter E. Engler
Director, Business Development

Developed for the Environmental Protection Service of Environment Canada, the EPS mobile UF/RO unit can be rented for on-site trails. Contact:

Mr. Harry Whittaker
Environmental Emergencies Technology Division
River Road Environmental Technologies Centre
Ottawa, Ontario
Canada
K1A 1C8
Telephone (613) 998-9622

OTHER DATA – Memtek is performing laboratory tests (Nov., 1983) of the unit with the EPS "Top 50" priority chemicals.

Memtek now manufactures a complete line of Reverse Osmosis and Ultrafiltration Units, custom-designed to a client's specific needs.

References: Memtek Brochures, correspondence with Peter Engler, Memtek Director of Business Development (November, 1983); personal communication, H. Whittaker (May 15, 1984); Manufacturers' Literature.

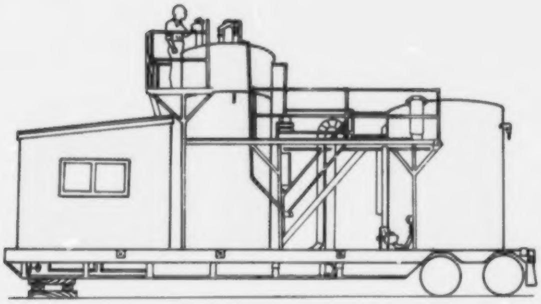
Whittaker, H., "Reverse Osmosis in Chemical Spill Control", Proceedings of the Technical Seminar on Chemical Spills, Toronto, Ontario, p. 93 (October 25-27, 1983), sponsored by the Technology Development and Technical Services Branch, Environment Canada.

PRODUCT PACT MOBILE WASTEWATER TREATMENT SYSTEM **No. 72**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – A mobile activated sludge/powdered carbon process for treating non-biodegradable and/or biodegradable organics in wastewater, groundwater and leachate. PACT stands for Powdered Activated Carbon Treatment.



OPERATING PRINCIPLE – Powdered activated carbon is mixed with activated sludge and the wastewater in a contact-aeration basin. The carbon particles adsorb waste components the micro-organisms cannot assimilate. The treated water is separated from the sludge and spent carbon through a clarifier and shallow-bed sand filter. Waste solids can be dewatered prior to disposal, hauled wet to an approved disposal facility, or directed to a powdered carbon regeneration step.

PHYSICAL SPECIFICATIONS – Four mobile wastewater treatment units are available:

Designation	Flow Capacity m^3/d(U.S. GPD)	Overall Dimensions* W x L x H m (ft)
PP-50	189 (50 000)	2.4 x 12.3 x 4.9 (8 x 40.5 x 16)
PP-100	378 (100 000)	3.6 x 12.8 x 3.6 (12 x 42 x 12)
PP-200	757 (200 000)	3.6 x 12.8 x 3.6 (12 x 42 x 12)
PP-300	1136 (300 000)	3.6 x 12.8 x 3.6 (12 x 42 x 12)

* without optional rapid sand filter

OPERATING SPECIFICATIONS – Ready to operate in two to three days once on site.

STATUS OF DEVELOPMENT AND USAGE – Commercially available on a lease basis, with an option to buy. Used for cleanup of groundwater, leachate or other site-specific wastewater problems.

PERFORMANCE – The mobile PACT system became available in 1983. Some full-scale PACT installations include:

Treatment of chemical processing wastes at Du Pont Co., Deepwater, NJ.

37 800 m^3 (10 million U.S. gal) per day at Medina County, OH.

A retrofit to an existing activated sludge system in Kimitsu, Japan, "proving to be nearly thirteen times more effective.... in reducing COD of high strength supernatants, and five times more effective in reducing BOD".

Removal percentages are claimed to be high (to 99.99 %) for base neutral extractables, acid extractables, volatile organics and pesticides.

AVAILABILITY AND COMMERCIAL INFORMATION – Units available on a lease basis with an option to buy.

Manufacturer:

Zimpro Inc.
Military Road
Rothschild, WI 54474
U.S.A.
Telephone (715) 359-7211
Telex 29-0495
Contact: Industrial Sales Department

OTHER DATA – Also see the Zimpro Zimmerman Wet Air Oxidation system described in section 5.3 of this survey.

Reference: Zimbro brochures No. W-301 (March, 1983) and No. W100-5 (December, 1982).

PROTOTYPE AMINE CARBAMATE GELLING AGENT AND APPLICATION SYSTEM **No. 73**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
		*				

DESCRIPTION – This prototype system is intended to facilitate recovery and control of hazardous liquids on water surfaces. A trimaran is equipped with: forward-mounted sprayers fed by an amine solution pumped from deck tanks; a liquid CO_2 transit tank and sparging system aft of the sprayers; and nets towed behind the craft to recover the gelled liquid.

OPERATING PRINCIPLE – The process depends on the reaction of CO_2 and an amine to form a carbamate salt: $R\text{-}NH_2 + CO_2 \rightarrow R\text{-}NH_2 - CO_2$. The spill is directed into the path of amine sprayers by sweeps or booms at the front of the trimaran, and then between the pontoon hulls. Liquid CO_2 is directed into this mixture, and the resulting carbamate solidifies the liquid mixture to white floating chunks of gelled material.

The solidified material is recovered by nets towed aft to the trimaran and then stored in bags or boxes for disposal. The hazardous liquid can be recovered by subjecting the gelled material to pressure filtration, with recovery also of the carbamate gelling agent which can then be converted to the starting amine by thermal decarboxylation.

PHYSICAL SPECIFICATIONS –

Amine solution (to be applied in about 15% concentration):

A three component solution is used:

70% Amine D™ (dehydroabiethylamine, manufactured by Hercules); 15% ethanol; and 15% Nopol (6,6-dimethyl - 2-norpinene).

Vessel:

Modular trimaran consisting of:

Pontoons which are perforated polycarbonate shells clamped around inflatable rubber bladders.

Deck of marine plywood panels laid over aluminum bracing.

Overall assembled length (without extended sweeps) 7.3 m (24 ft); width 3.7 m (12 ft), draft with full loading 0.4 m (15 in) freeboard 0.5 m (18 in).

Can be disassembled, stored and transported in a 2.5 x 3.7 x 1.8 m (8.2 x 12.1 x 5.9 ft) truck trailer with all requirement equipment and supplies.

Ancillary Equipment:

- Eight 206 L (55 U.S. gal) drums of Amine D solution.
- CO_2 transit tank (320 kg (700 lb) capacity) with hose and sparging system.
- Two metering pumps for the Amine D solution.
- Two metering pumps for the Amine D solution.
- Two Amine D sprayers.
- 220 V electrical generator (gasoline powered) and GFI (Ground Fault Interrupter) equipment.
- Forward-mounted sweeps for increased width of intake area.
- Two 25 hp marine engines.
- Life rafts, life jackets, tool and damage control locker.
- For situations involving recovery and control of more than 20 000 L (5283 U.S. gal) of hazardous liquid spills on water surfaces, a back-up CO_2 transit tank and additional drums of Amine D solution are recommended by the manufacturer.

Vessel designed for operation in inland waters or in situations with less than 0.5 m (1.6 ft) harbor chop.

Craft will support a load of 5 tonnes of equipment and supplies, at a fully laden speed of about 6.5 km/h (3.5 knots), and can cover an area of about 0.4 hectares (1 acre) in a track 5.0 m wide by 0.8 km (16.5 ft x 1/2 mile) with 8200 L (2166 U.S. gal) of hazardous liquid spill, in less than 10 minutes.

Recovery nets towed by auxiliary craft stationed behind the trimaran could be deployed to recover the gelled hazardous liquid.

Assembly and loading of the trimaran can be accomplished at a boat landing, or by lowering raft and component equipment from overhead bridges to water surface by means of a one-ton crane. (Can be assembled in less than two hours.)

STATUS OF DEVELOPMENT AND USAGE – Prototype successfully tested at U.S. Naval Submarine Base, New London, CT on December 17, 1979 and successfully used there later on an actual spill. No quantitative results.

No indication was received of development beyond the prototype stage.

PERFORMANCE – Tests indicate that this system may be applicable to spills of the following chemicals:

Benzene
Ethylbenzene
Styrene (Monomer)
Cumene
Methyl Isobutyl Ketone
Turpentine
Toluene
Xylenes
2-Ethylhexanol
Cyclohexane
n-Hexane

This system also shows possible application to spills of:
Butyraldehydes
Methyl Isobutyl Carbinol
Methyl Methacrylate
Tall Oil
Ethyl Chloride

AVAILABILITY AND COMMERCIAL INFORMATION –

Patents: U.S. 3 684 733 and 3 880 569.

Manufacturer:

University of Lowell
Lowell, MA 01854
U.S.A.
Telephone (617) 452-5000, Ext. 2509
Contact: Dr. W. Bannister

Cost (December, 1981):

Trimaran craft and all equipment: $84 000
200 kg (441 lb) drum of Amine D solution: $1080
Liquid CO_2: Refill of transit tank - approximately $360

OTHER DATA – No information.

References: Manufacturer's Literature; Report of Commanding Officer, Naval Submarine Support Facility, New London to Commander, Naval Facilities Command (February 25, 1980).

PRODUCT CHEM-GEL AND INDUSORB **No. 74**

APPLICABILITY	Gas	Liquid			Solid		
		Sol	Fl	Sk	Sol	Fl	Sk
		*	*	*			

DESCRIPTION – CHEM-GEL is a combination of both an absorbent and adsorbent which gels aqueous solutions, alcohols, and polar and nonpolar organics on land or floating on water. INDUSORB is designed to absorb water and aqueous solutions of polar and nonpolar solvents, acids, alkalis and hydrocarbon products.

OPERATING PRINCIPLE – These gelling agents are dry solids which agglomerate hazardous chemicals into a gel that is easily picked up using physical/mechanical methods.

PHYSICAL SPECIFICATIONS – Dry powders or flakes are available in 22.7 kg and 0.4 kg drums or 4 to 44 kg boxes (50 lb and 45 lb drums or 4 to 10 lb boxes).

Chem-gel:	White, odourless, polymeric powder. Specific Gravity 0.34.
Indusorb:	Light brown to white, odourless, polyacrylonitrile granules or flakes. Specific Gravity 0.38.

OPERATING SPECIFICATIONS –

Chem-gel:

Hygroscopic - must be stored in a dry location.
Resulting gel will retain the hazardous nature of the chemical involved (i.e. flammable, toxic, poisonous, caustic, etc.).
Will not support combustion when ignited by a methanamine tablet or subjected to the flame of a propane torch.
Flash point of the gelled mixture MAY BE lower than that of the chemical alone.
Gel time will vary from 10 seconds to 30 minutes depending on the amount of Chem-gel used.
Absorption Ratio: up to 100:1.
Absorption Rate: 0.25 to 7 minutes.

Indusorb:

Effective only in the presence of water.
Yields a non-flammable gel from aqueous mixtures not exceeding 10% chemical content.
Suggested application rate: 1 g/50 cm^3 (1 lb/6 U.S. gal) of liquid mixture.
Will char but not support combustion when subjected to a 1370°C (2500°F) flame.

Three dispersion systems are recommended:

1) Pressurized Tank System:

a) Portable: Rechargeable CO_2 - charged dry chemical fire extinguisher (e.g., Ansul Company Model A-1-C).

b) Semi-portable: Large reservoir and air compressor. For example, a 1.8 m (6 ft) diameter, 4.6 m (15 ft) truck-mounted tank, equipped with a gas-powered air compressor, would hold approximately 2270 kg (5000 lb) of powder at 3/4 capacity. (A similar delivery system is commercially available from the MSA Co., Pittsburg, PA.)

2) Venturi/Compressed Air System:

Sized between the portable fire extinguisher and large tank systems, the Econo-Vac sandblasting unit (Airplaco, Clipper Manufacturing Company, Kansas City, MO, Model EV-14M) typifies available hardware. It delivers approximately 1.6 kg (3.5 lb) of powdered Chem-gel per minute with the venturi feed tube placed directly into a fiber drum of Chem-gel.

3) Auger-Fed/Pneumatic Conveyor System:

A unit which auger-feeds powdered gelling agent from a hopper into a moving air stream provides rapid delivery of high volume over a spill area. A typical unit is the Bantam 400 Rockduster (described in this survey).

STATUS OF DEVELOPMENT AND USAGE – Marketed for many industrial sorbent applications.

PERFORMANCE –

Chem-gel: Claimed to improve the efficiency of floating booms by increasing the thickness of the floating chemical layer. Gelling efficiency of powdered chem-gel:

Class	Test Liquid	Gelling Ratio	Minutes to Gel	
I	WATER SOLUBLE	1. Sat. Chlorine Water	10/1	1.5
		2. Ammonium Hydroxide	10/1	1.0
		3. Water	10/1	0.5
II	NON-POLAR ORGANICS	1. Kerosene	5/1	1.5
		2. Benzene	10/1	0.25
		3. Cyclohexane	10/1	2.5
III	POLAR ORGANICS	1. o-Dichloro Benzene	10/1	0.33
		2. Ethylene Dichloride	10/1	0.25
		3. Carbon Tetrachloride	10/1	0.75
IV	ALCOHOLS	1. Methanol	10/1	6.0
		2. Ethylene Glycol	5/1	7.0
		3. Isopropanol	10/1	3.0

Indusorb: Independent lab tests (Commercial Chemists, Inc., Jacksonville, FL) have shown:

1) Indusorb reduced the flash and fire points of the following mixtures (10 cm^3 chemical/90 cm^3 water):

   Acetone
   Exxon Unleaded Gasoline
   No. 1 Diesel Oil
   Rapco Automotive Diesel Fuel

2) Indusorb helped suppress the vapours of a heptane, ethyl alcohol, acetone, water solution.

3) Indusorb inhibited the ignition or flaming of a 10% no. 1 Diesel Oil mixture in water when exposed to the cutting of a steel plate by an oxygen-acetylene torch 0.6 m (2 ft) above the surface of the mixture.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Industrial Services International, Inc.
P.O. Box 10834
Bradenton, FL 33507
U.S.A.
Telephone (813) 792-7778

Distributor:

Elmer Clark
President
E.S. Clark Associates, Inc.
P.O. Box 40524
Jacksonville, FL 32203
U.S.A.
Telephone (904) 384-4393

OTHER DATA – Indusorb has also been known as Terrasorb. The name change reflects avoidance of a trade name conflict with Terra-Sorb T-200.

References: Product Data from E.S. Clark Associates, Inc., including independent laboratory results from Commercial Chemists, Inc., Jacksonville, FL, (October, 1983).

CONCEPT CONTAINMENT OF RADIOACTIVE WASTES BY ION EXCHANGE **No. 75**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*			*		

Note: Applicable to spills of liquids or solids on land.

DESCRIPTION – A conceptual method of containing and removing radioactive spills by depositing cross-linked ion exchange composition in dry form over the region of the spill. The ion exchange composition, which can be in powder or solid form (such as cloth), removes contaminants from a spill by exchanging radioactive ions for a non-radioactive species.

OPERATING PRINCIPLE – The dry powdered or sheet-like ion exchange composition is deposited over the spilled material, particularly in the flow direction, to absorb the solution and prevent its spread, percolation and absorption into the surface on which the spill occurred. Radioactive ions are exchanged for non-radioactive ions in the ion exchange material.

PHYSICAL SPECIFICATIONS – A resin with good adsorption and ion exchange capability should have 16 to 50 mesh particle size and 0.25 to 25% cross-linking.

Organic and inorganic ion exchange resin will hold radioactive nuclides.

OPERATING SPECIFICATIONS – Absorption capabilities of the ion exchange resin are enhanced by a cross-linking agent such as divinyl-benzene (DVB).

Mol. % DVB in the Ion Exchange Resin	Ratio of the volume of liquid absorbed to the initial dry volume of resin
0.25	50
0.5	22
1.0	10
2.0	7
3.5	5
10	<2

Ion exchange capabilities of the resin are dependent on its dry weight.
Ion exchange resins are used to treat liquid and solid radioactive spills.
Treatment is conducted on site.
Ion exchange resin containing radioactive ions can be cleaned and reused or disposed of in an appropriate site.

STATUS OF DEVELOPMENT AND USAGE – A patented concept (U.S. Patent 4 056 112) developed by Mr. Calvin Calmon. No information regarding its commercial development was available.

PERFORMANCE – Use with hazardous materials has not been documented.

AVAILABILITY AND COMMERCIAL INFORMATION –

Commercial production pending.

Mr. Calvin Calmon
Arneys Mount Road
Birmingham, NJ 08011
U.S.A.

OTHER DATA – None obtained.

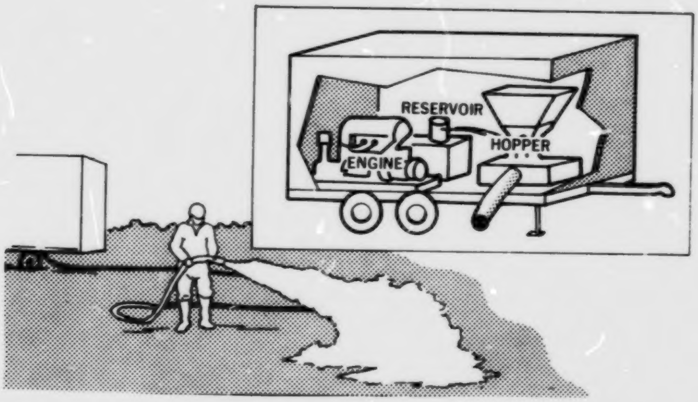
PROTOTYPE EPA MULTIPURPOSE GELLING AGENT **No. 76**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

Note: Liquids sinking in water can be gelled if agitated and dispersed through the water column.

DESCRIPTION – Prototype development. A formulation of four commercially available gelling agents, plus fumed silica, which transforms aqueous liquids, chlorinated organics, alcohols and nonpolar hydrocarbons into a semi-solid mass.



OPERATING PRINCIPLE – Each component of the gelling agent selectively interacts with the spilled chemicals to create an immobile gel which can be removed by mechanical means (e.g., shovel, screen).

PHYSICAL SPECIFICATIONS –

Component	% of Blend	Reacts With	Trade Name (Manufacturer)
1) Highly water-soluble polyelectrolyte e.g., polyacrylamide, gelatin, casein	5	Aqueous liquids	Gelgard M (Dow)
2) Cross-linked copolymer e.g., polytertiary - butyl styrene copolymerized with divinyl-benzene	30	Non-polar liquids and weak solvents e.g., cyclohexane, gasoline fractions	Imbiber Beads (Dow)
3) Polyacrylonitrile-butadiene copolymer	30	Polar organics e.g., acrylonitrile, ethylene dichloride	Hycar 1422 (B.F. Goodrich)
4) Polycarboxylmethy-cellulose polymers or polyethylene oxide material or polysaccharide exudates	25	Alcohols e.g., methyl alcohol	Carbopol 934 (B.F. Goodrich) Polyox (Union Carbide)
5) Fumed Silica	10	Slowly reacts with organics but provides long-term resistance to hydrolysis, stiffer gel; fluidizer.	Cabosil (Cabot Corp.)

A prototype Mobile Dispensing System (MDS) has been developed for the U.S. EPA to dispense the Multipurpose Gelling Agent.

4 m (13 ft) enclosed utility trailer which can be towed to spill sites by a three-quarter ton vehicle.

Air-cooled gasoline engine to power an auger-fed/pneumatic conveyor.

60 m (200 ft) of 51 mm (2 in) delivery hose.

Delivery rate: 5.4 kg (12 lb)/min, 2 to 6 m (6.5 to 19.7 ft) from the nozzle.

OPERATING SPECIFICATIONS – The gelling agent is spread directly onto spills on land (stagnant or flowing) or on water (calm or slow moving).

Approximately 1 kg (2.2 lb) of agent can gell 10 L (2.6 U.S. gal) of spilled liquid.

STATUS OF DEVELOPMENT AND USAGE – A final formulation of the Multipurpose Gelling Agent was developed under EPA Contracts 68-01-0110 and 68-01-2093 by Calspan Corporation. An operational prototype of a Mobile Dispensing System was developed, tested and delivered to the U.S. EPA by May 1977.

PERFORMANCE –

Typical compounds immobilized by the Multipurpose Gelling Agent:

Acetone
Acetone Cyanohydrin
Acrylonitrile
Ammonium Hydroxide
Aniline
Benzaldehyde
Benzene
Butanol
Carbon Disulphide
Carbon Tetrachloride
Chlorine Water (saturated)
Chloroform
Cyclohexane
Cyclohexanone
o-Dichlorobenzene
Ethanol
Ethylacetate
Ethylene Dichloride
Ethylene Glycol
Formaldehyde
Gasoline
Isoprene
Isopropyl Alcohol
Kerosene
Methanol
Methyl Ethyl Ketone
Octane (2,2,4 Trimethyl Pentane)
Petroleum Ether
Phenol (89%)
Pyridine
Sulphuric Acid
Tetrahydrofuran
Trichloroethylene
Water
Xylene

Calspan performed tests of minor and major spills of hazardous materials during October, 1976 at Bethany, NY. Minor spills (76 L (20 U.S. g)) were contained within 23 m (75 ft) ditches of 19° slope.

76 L (20 U.S. gal) Chemical Spills:

Calspan Bethany, NY Demonstration Site

Chemical	Class	Spill rate L/min (gal)/min	MGA used kg (lb)	Amount of MGA used per litre spilled kg/L	Distance spill stopped m (ft)
Water**	Aqueous	151.4 (40)	9.1 (20)	0.12	2.4 (8)
Kerosene*	Hydrocarbon	151.4 (40)	40.8 (90)	0.54	6.1 (20)
Trichloroethylene*	Chlorinated	151.4 (40)	18.1 (40)	0.24	6.1 (20)
Methanol*	Alcohol	151.4 (40)	20.4 (45)	0.27	6.1 (20)

* Air Temp 0°C (32°F), Wind 8 to 16 km/h (5 to 10 m/h)
** Air Temp 7°C (45°F), Wind 8 km/h (5 m/h)

Gelling was conducted of about 950 L (250 U.S. gal) pH 3.0 sulphuric acid solution spilled into a 76 cm (30 in) wide trench running 9 m (30 ft) into an open pool. The surface gelled to a depth of approximately 5 to 10 cm (2 to 4 in). Without external mixing, this top layer prohibited further penetration of the gelling agent.

These field trials showed two persons could operate the MDS: one operating the engine and conveyor system and another directing the agent onto the spill area.
Similar tests were performed again for members of the U.S. EPA on November 4, 1976 with similar results.

AVAILABILITY AND COMMERCIAL INFORMATION – The Multipurpose Gelling Agent was developed by:

Calspan Corporation
Environmental Systems Department
P.O. Box 400
Buffalo, NY 14225
U.S.A.
Telephone (716) 632-7500
Telex 91-270

for Oil and Hazardous Materials Spills Branch
Industrial Environmental Research Laboratory-Ci
U.S. Environmental Protection Agency
Edison, NJ 08837
U.S.A.
Telephone (201) 321-6634
Contact: Joseph P. Lafornara, Project Officer

OTHER DATA – No additional information obtained.

References: Michalovic, J.G., C.K. Akers, R.W. King and R.J. Pilié, R.J., Calspan Corporation, System for Applying Powdered Gelling Agents to Spilled Hazardous Materials, U.S. Environmental Protection Agency, Report EPA-600/2-78-145 (1978).

Baier, R.E., J.G. Michalovic, V.A. Depalma and R.J. Pilié, Calspan Corporation, "Universal Gelling Agent for Control of Hazardous Liquid Spills", Journal of Hazardous Materials, 1 pp. 21-33 (1975/76).

PRODUCT MUCK-UP ADSORBENT/SOLIDIFYING AGENT **No. 77**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – A dry, granular adsorbent which "solidifies oily wastes" (water insoluble) such as PCBs, toluene and solvents.

OPERATING PRINCIPLE – Liquids are physically adsorbed to the sorbent granules to form a homogeneous, non-flowing mixture.

PHYSICAL SPECIFICATIONS – Calcium Aluminum Silicate (Montmorillonite) granules available in 15.9 kg (35 lb) pails.

Typical Analysis

Water Soluble
Reacts with: Hydrofluoric Acid (HF)
Color: Tan
pH: 5.8
Specific Gravity: 2.2
Bulk Density: 500 kg/m^3 (31 lb/ft^3)
104 kg (228 lb)/55 U.S. gal drum
Screen Analysis: 0.2% + 20 mesh, 1.5% - 60 mesh
Water Adsorption: 1.1 mL/g or 114 L (30.1 U.S. gal)/55 U.S. gal drum
Oil Adsorption: 0.95 mL/g or 98 L (26 U.S. gal)/55 U.S. gal drum
Cost (Nov. 82): $17.50 US/15.9 kg (35 lb) pail

OPERATING SPECIFICATIONS – Muck-Up can be applied directly to a spill and scooped into the 19 L (5 U.S. gal) pail provided. It can also be mixed in a revolving drum with waste materials to bind it thus making it safer to transfer to ultimate disposal facilities.

STATUS OF DEVELOPMENT AND USAGE – Marketed for cleanup of: paints spills, unkown water-insoluble chemicals, PCBs, acids and caustics, bunker fuel, gasoline, naphtha, insecticides, rodenticides, and fumigants. Suggested as an absorbent packing material for the transport of hazardous material containers.

PERFORMANCE – Use of Muck-up in response to hazardous material spills has not been documented.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Mateson Chemical Corporation
1025 E. Montgomery Avenue
Philadelphia, PA 19125
U.S.A.
Telephone (215) 423-3200
Contact: Mr. Jean F. Mateson, President

OTHER DATA – Some of Mateson's other products:

FOUL-UP: Adsorbent and deodorant (charged with CTC) for water adsorption and solidification of water-based (sewage, animal wastes) spills.

LIQUIVAC: An additive to tap water that will overcome insoluble pollutants, capture and neutralize odour and acid fume problems. Neutralizes acid wastes.

PRODUCT SPILL/CLEAN GELLING AGENT **No. 78**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

Note: Applicable only to spills of liquid on land.

DESCRIPTION – An agent which absorbs spilled hazardous materials by a physical process producing a gel. This gelling agent is made of a series of co-polymers.

OPERATING PRINCIPLE – Spill/Clean is applied on the spilled liquid until gelling of the mixture occurs.

PHYSICAL SPECIFICATIONS – Packaged in 11.4 kg (25 lb) fibre drums (0.76 m (2.5 ft) tall and 0.46 m (1.5 ft) dia.) or larger packages if necessary.

OPERATING SPECIFICATIONS –

Reacts like a gel for liquids on land (only).
Claimed to be suitable for "most acids, caustics, flammable solvents and other hazardous or non-hazardous liquids".

STATUS OF DEVELOPMENT AND USAGE – Commercially available and widely purchased by chemical industries, hospitals, airports and government agencies.

PERFORMANCE – Will not gel fuming nitric acid.

Ratios of solvent volume to weight of Spill/Clean for selected chemicals are as follows:

Chemical	Vol. to Wt. Ratio
Nitric Acid	4.5 : 1
Sulphuric Acid	7.5 : 1
Sodium Hydroxide	10.0 : 1
Potassium Hydroxide	9.0 : 1
Gasoline	11.0 : 1
No. 2 Fuel Oil	5.0 : 1
Benzene	9.0 : 1
Trichloroethylene	7.0 : 1
Petroleum Ether	12.0 : 1

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

United States Testing Co., Inc.
Environmental Sciences Division
1415 Park Avenue
Hoboken, NJ 07030
U.S.A.
Telephone (201) 792-2400
Contact: Mr. D. Hansen

OTHER DATA – No additional data obtained.

Reference: Manufacturer's Literature; personal communication, Mr. D. Hansen, United States Testing Co., Inc. (26, 28 January, 1982).

CONCEPT PATENTED SPILL CONTROL COMPOSITIONS No. 79

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – Patented Concepts. Spill control compositions formulated to neutralize small volume liquid chemical spills in enclosed environments.

OPERATING PRINCIPLE – Acids, caustics, cyanides and mercury are treated by mixing reagents with the spilled materials.

PHYSICAL SPECIFICATIONS – Composition (wt. %) of the neutralizing mixtures used for the treatment and clean-up of spilled:

Hydrofluoric Acid:

25 to 29% of calcium acetate
71 to 75% water and a mixture of
99.90 to 99.99% magnesium oxide, and
0.01 to 0.10% pH indicator, preferably bromothymol blue.

Other Mineral Acids:

36.5 to 47.5% calcium carbonate
35 to 45.5% sodium carbonate
16.5 to 21.5% magnesium oxide, and
0.008 to 0.012% solid pH indicator, preferably bromothymol blue.

Caustic Alkalis:

51 to 81% citric acid
12 to 21% expanded perlite
12 to 21% flour
1.2 to 2.1% fumed silica
0.01 to 0.50% pH indicator, preferably bromothymol blue, and
1 to 3% water.

Cyanides:

78 to 82% ferrous sulphate
18 to 22% alkali or alkaline earth metal carbonate, preferably sodium carbonate.

Mercury:

41 to 52% zinc or copper granules
41 to 52% zinc or copper powder, and
5 to 9% sulfamic acid.

OPERATING SPECIFICATIONS – pH indicator must undergo a perceptible colour change in the pH 6.0 to 8.0 range.

Neutralizing mixtures are activated with water prior to application to the spill in paste or liquid form.

Acids and Alkalis:

The activated neutralizing mixture is left on the spill until the pH indicator exhibits the appropriate colour change for neutral pH.

The neutralized acid or alkali mixture is absorbed onto sawdust and disposed of.

Cyanide and Mercury:

The activated neutralizing mixture is placed on the cyanide or mercury spill for sufficient time to adsorb the cyanide or mercury (approximately 5 minutes).

Neutralized spill disposed of as for acids and alkalis.

STATUS OF DEVELOPMENT AND USAGE – Use of these patented concepts with hazardous materials has not been documented.

PERFORMANCE – Evaluation data not available.

AVAILABILITY AND COMMERCIAL INFORMATION – These spill control compositions were patented by James W. Seidenberger, Bethlehem, Pennsylvania and assigned to the J.T. Baker Chemical Company.

U.S. Patents: 3 975 298, 3 994 821, 4 011 098, 4 105 576, and 4 210 460.

J.T. Baker Chemical Company
222 Red School Lane
Phillipsburg, NJ 08865
U.S.A.
Telephone (201) 859-2151

OTHER DATA – Commercial products are available from J.T. Baker for cleaning up solvent spills (SOLUSORB) and mineral acid spills (NEUTRASORB).

2.8 Fundamental Wastewater Treatment Techniques

No. 80

The feasibility was examined of physical and chemical wastewater treatment techniques as hazardous material spills countermeasures (1, 2, 3, 4, 5). These techniques include:

Chemical

A. Biodegradation
B. Chelation
C. Chemical Oxidation/Reduction
D. Neutralization
E. Photochemical Oxidation/Reduction

Physical

F. Carbon Adsorption
G. Ion Exchange
H. Precipitation, Flocculation and Sedimentation
I. Reverse Osmosis
J. Solvent Extraction
K. Ultrafiltration
L. Wet Air Oxidation

The following sections deviate from the standard format of the survey. They briefly summarize each wastewater treatment technique. The reader is directed to product entries, where applicable, in the survey which complement the review. References are also cited throughout this discussion and appear in numbered sequence to conclude the section.

2.8.1 Chemical Wastewater Treatment

A Biodegradation

Biological oxidation of dissolved organic matter to simple organic or inorganic end products occurs through micro-organisms growing in either aerobic (with oxygen) or anaerobic (without oxygen) environments. Aerobic oxidation is most commonly used since it is easier to operate than anaerobic processes and the end products are more acceptable than those of anaerobic digestion (e.g., water, carbon dioxide, sulphates versus methane, mercaptons and hydrogen sulphide).

Aerobic oxidation processes are more commonly known as activated sludge systems. The sludge (biomass of organics in solution) is active when oxygen and nutrients (N,P) are maintained in sufficient quantities to support the metabolism of the micro-organisms. Activated sludge, as well as anaerobic oxidation, will not function with wastes of high concentrations of toxins (e.g., heavy metals) and refactory organics (e.g., tertiary butyl alcohol or pyridine) and/or wastes of extreme pH levels(1).

Biodegradation has been considered a hazardous material countermeasure of limited use because of the sensitivity of micro-organisms to their environment and the hazards which could be introduced through the organisms themselves if not properly controlled. However, mobile activated sludge processes have been developed (e.g., UNOX Process of Union Carbide(2)) and successful cases of in-situ treatment (i.e., micro-organisms active in a semi-controlled natural environment) have demonstrated the long-term cleanup capabilities of biodegradation.

The following table summarizes biodegradation techniques now employed.

B Chelation

Chelating agents are compounds or ligands (generally organic) that bind a metal ion to more than one position on the chelating agent. This binding prevents the metal from reacting chemically, thus reducing its toxicity.

There are two groups of chelating agents: 1) sequestrants which bind the metal ion but remain soluble in water; and 2) precipitants which form insoluble complexes.

EDTA (ethylenediaminetetraacetic acid) has been identified as a promising sequestering chelating agent(1). It forms stable complexes with copper, nickel, zinc, cadmium, iron and other heavy metals. EDTA is less effective with silver, antimony and titanium and compounds such as potassium dichromate, potassium permanganate, chromic anhydride and sodium ferrocyanide.

Oxine (8-hydroxyquinoline), a precipitant, performs like EDTA, but is limited in application due to its low solubility. EDTA is widely available (used in the food and medicine industries) and is lower in toxicity than oxine.

Chelating agents may be useful for detoxifying spills containing heavy metals, but the ultimate removal of the resultant ligand-metal complexes must be made using other wastewater treatment techniques, such as reverse osmosis or solvent extraction.

OVERVIEW OF BIOLOGICAL TREATMENT PROCESSES (4)

Biological Process	Principal Microbial Population	Optimum Temperature	Range (in pH)	% Solids in Waste Stream	Average Retention Time	Organic Decomposed	Estimated BOD Upper Limits Effectively Handled (mg/L)	Effluent	Residue	Energy Demand (% of total cost)	Chemical Demand (% of total cost)	Total Cost ($/1000 gal)
Enzyme Treatment	None	Mesophilic	1.5 to 9.5 varies per enzyme	< 50	Nil	all can be decomposed by a series of enzymes	No limit	CO_2 and water if complete treatment, otherwise intermediate decomposition products	None	<10	<10	Prohibitive production and immobilization cost
Activated Sludge Treatment	Aerobic heterotrophic bacteria	Mesophilic	6 to 8	<1	<1 day	all but oil, grease and halogenated aromatics, nitrogen compound	<10 000	CO_2 and water, 5 to 15% influent BOD remains	Biomass sludge	>10	>10	<5
Trickling Filter	Aerobic heterotrophic bacteria	Mesophilic	6 to 8	<1	<1 day	all but oil, grease and halogenated aromatics, nitrogen compound	<5000	CO_2 and water, 10 to 20% influent BOD remains	Biomass sludge	<5	>10	<3
Aerated Lagoon	Aerobic heterotrophic bacteria and facultative anaerobic heterotrophic bacteria	Mesophilic	6 to 8	<1	2-7 days	all but oil, grease and halogenated aromatics, nitrogen compound	<5000	CO_2 and water, 10 to 30% influent BOD remains	Biomass sludge	>10	>10	<3
Waste Stabilization Pond	Aerobic heterotrophic bacteria and autotrophic algae	Mesophilic	6 to 8	<0.1	3-6 months	mostly carbohydrates proteins, organic acids and alcohols	<100	CO_2 and water, 1 to 10% influent BOD remains	None	<5	<5	<2
Anaerobic Digestion	Obligate anaerobic heterotrophic bacteria	Thermophilic	6.4 to 7.5	<10	2 weeks	mostly carbohydrates proteins, organic aci is and alcohols	Not applicable	Mixed liquor of biomass and interstitial water; 40 to 50% influent volatile sludge solids remain	"Stabilized" sludge	<5	<5	<15
Composting*	Aerobic heterotrophic bacteria and facultative anaerobic heterotrophic bacteria and fungi	Mesophilic and Thermophilic	5 to 8.5	< 50	3-6 months	all organics, phosphorus compounds and nitrogen compounds	No limit	Leachate with soluble organics	None	<5	>10	<30

* see Section 5.4 Biodegradation in this survey.

Consult directories of manufacturers such as Fraser's Canadian Trade Directory, Thomas Register of American Manufacturers ("Thomcat" directory) or the annual Chemical Week Buyer's Guide under "Water Treatment (Chemicals) for suppliers of chelating agents.

C Chemical Reduction/Oxidation

Reduction/Oxidation ("Redox") reactions constitute a transfer of electrons from one species to another. The species accepting electrons (becoming more negatively charged) are reduced and the species losing electrons (becoming more positively charged) are oxidized. For example:

$$2MnO_4^- + CN^- + 2OH^- \rightarrow 2MnO_4^{2-} + CNO^- + H_2O$$

Permanganate Cyanide → Manganate Cyanate

Cyanide acts as the reducing agent, transferring one electron to permanganate and reducing it to manganate. Simultaneously, cyanide is oxidized to cyanate which has one less electron than cyanide. Therefore, oxidizing agents are themselves reduced when inducing oxidation and reducing agents are similarly oxidized when reducing another species.

Redox reactions can be used to change hazardous species into less harmful forms.

Oxidation. Oxidizing agents include fluorine, hydrogen peroxide (H_2O_2), permanganate (MnO_4^-), chlorine, dichromate ($Cr_2O_7^{2-}$) and air. Fluorine is the strongest oxidizer, but rarely used for industrial applications because of the hazards involved in handling and controlling it. Air is the safest oxidizer (easily handled, no overdose hazards) and offers other benefits such as precipitating ferrous iron, oxidation of sulphites and hydrogen sulphide, and stripping volatile materials from wastewaters(4). However, oxygen is only slightly soluble in water. Therefore, oxidation by aeration requires equipment to deliver large volumes of air and time to provide complete oxidation.

Most oxidants have been used for treatment of inorganic compounds, notably cyanide, as indicated. Potassium permanganate ($KMnO_4$), hydrogen peroxide, and ozone have been used to oxidize organics.

Wastes Treated by Oxidants(4)

Oxidant	Waste
Ozone	(a)
Air (atmospheric oxygen)	Sulphites (SO_3=) Sulphides (S=) Ferrous iron (Fe++) — very slow
Chlorine gas	Sulphide Mercaptans
Chlorine gas and caustic	Cyanide (CN^-)
Chlorine dioxide	Cyanide Diquat Paraquat - pesticides
Sodium hypochlorite	Cyanide Lead
Calcium hypochlorite	Cyanide
Potassium permanganate	Cyanide - organic odors
Trace quantities only	Lead Phenol Diquat Paraquat - pesticides Organic sulphur compounds Rotenone Formaldehyde
Permanganate	Manganese
Nitrous acid	Benzidene

Oxidant	Waste
Hydrogen peroxide (8)	Phenol Cyanide Lead Hydrogen Sulphide Polysulphides Hydrosulphite Dithionite Polythionate Thiosulphate Thiols, Mercaptans Aldehydes Hydroquinone

(a) See also PHOTOCHEMICAL OXIDATION/REDUCTION, section 1.5 of this review, for further discussion regarding ozone.

Oxidizing agents may react violently in the presence of significant quantities of readily oxidizable organics. Therefore, these agents should be well mixed and added slowly to spills to avoid momentary excesses and violent reactions. Oxidation reaction times occur within seconds to minutes.

Waste solutions to be treated by chemical oxidation must be pH-adjusted to assure efficient oxidation. For example, phenol will oxidize in the range of pH 5 to 6, while cyanides require more alkaline conditions (pH 8.5 to 10)(7). This requirement can limit the applicability of oxidation in a spill situation where immediate response and limited control make preparation of the spill site difficult.

Carbon dioxide, water, partially oxidized organics (i.e., short chain organics from long chain compounds) and insoluble inorganics are the common products of chemical oxidation. The latter two products may require further treatment such as carbon adsorption and sedimentation. Oxidizing agents, such as oxygen and hydrogen peroxide, have the advantage that they introduce no additional foreign ions to the mixture.

Reduction. Commonly used reducing agents include sulphates (e.g., sodium thiosulphate), sulphites (e.g., calcium sulphite), sulphur dioxide, and waste iron. (Domestic sewage has been suggested as the 'best' reductant, its reducing power increasing with oxygen demands (BOD and COD) (6, p. 4 to 11). Adding domestic sewage to a hazardous spill is a matter left to the discretion of the reader!)

Wastes Treated by Reductants(4)

Reductant	Waste
Sulphur dioxide (often flue gas)	Chromium (VI)
Sulphite salts sodium bisulphite sodium metabisulphite sodium hydrosulphite	
Ferrous sulphate	
Waste pickle liquor	
Powdered waste iron	
Powdered waste aluminum	
Powdered metallic zinc	
Sodium borohydride ($NaBH_4$)	Mercury-containing
Sodium borohydride	Tetra-alkyl-lead
Sodium borohydride	Silver

As the above table indicates, reducing agents have been used primarily for treating inorganics, notably chromium. These agents lower the oxidation state (e.g., Cr^{+6} to Cr^{+3}) of a substance, reducing its toxicity or solubility, or transforming it into more easily handled forms.

The end products of reduction are similar to those of oxidation reactions. Quantities of esters large enough to cause odour problems may evolve when reducing heavy metals from waste oil. The effluent solutions containing reducing sodium borohydride and zinc are typically acidic and should be neutralized before discharge, using materials such as hydrated lime, caustic soda or soda ash(4).

In general, redox reactions are most efficient when controlled in wastewater treatment systems, such as:

	Entry No.
EPA Mobile Physical/Chemical Treatment Trailers	69
EPA Mobile Flocculation - Sedimentation System	68
EPA/Met-Pro Mobile Independent Physical/Chemical Wastewater Treatment System	67

D Neutralization

Strong bases are the most economical (i.e., smallest amount required) reagents for the neutralization of strong acids - and vice versa. However, excess application of strong neutralizers can result in extreme pH levels (i.e., outside the range of 6 to 9) which are as hazardous as the original spilled chemical. Consequently, sodium dihydrogen phosphate (NaH_2PO_4) has been identified as the most promising agent for neutralizing basic or alkaline spills and sodium bicarbonate ($NaHCO_3$) as the most promising neutralizing agents for acid spills(1). (The pH range of 6 to 9 is representative of natural waters.)

Misapplication of I.O.M. sodium dihydrogen phosphate could result in a pH as low as 4.5. This is safer than pH 0.3 for 1.0 m sulphuric acid or pH 2.4 for 1.0 M acetic acid. Similarly, an overshoot of a 1.0 M sodium bicarbonate solution would yield a pH of 8.3 compared to pH 12.4 for a 0.024 M solution of lime. (Lime is less expensive and more readily available than sodium bicarbonate but these characteristics could lead response personnel to apply excessive amounts to an acid spill when sodium bicarbonate would neutralize a spill with greater safety.)

Chemicals Recommended for Neutralization by Sodium Bicarbonate(1)

Acids	Compounds Reacting with Water to Give Acids
Acetic Acid	Acetic Anhydride
Acrylic Acid	Aluminum Chloride
Formic Acid	Benzoyl Chloride
Hydrochloric Acid	Bromine
Hydrofluoric Acid	Chlorosulphonic Acid
Hydrogen Chloride	Maleic Anhydride
Sulphuric Acid (spent)	Nitrogen Tetroxide
Hydrogen Fluoride	Nitrosyl Chloride
Nitric Acid	Oleum
Oxalic Acid	Phosphorus Oxychloride
Phosphoric Acid	Phosphorus Pentasulphide
Propionic Acid	Phosphorus Trichloride
Sulphuric Acid	Polyphosphoric Acid
	Sulphur Monochloride
	Sulphuryl Chloride
	Titanium Tetrachloride

Bases	Compounds Reacting with Water to Give Bases
Aminoethylethanolamine	Sodium
Ammonium Hydroxide	Sodium Amide
Caustic Potash Solution	Sodium Hydride
Caustic Soda Solution	Anhydrous Ammonia
Cyclohexylamine	Ethyleneimine
Diethynolamine	Lithium Aluminum Hydride
Diethylamine	
Diethylenetriamine	
Diisopropanolamine	
1,1-Dimethylhydrazine	
Ethylenediamine	
Hydrazine	
Monoethanolamine	
Monoisopropanolamine	
Morpholine	
Potassium Hydroxide	
Sodium Hydroxide	
Triethanolamine	
Triethylamine	
Triethylenetetramine	
Trimethylamine	
Hexamethylenediamine	

Neutralization of basic spills in streams or ponds using sodium dihydrogen phosphate may or may not result in an increase in algal growth as phosphate is usually a limiting growth nutrient of aquatic flora.

Natural dispersion of streams or ponds will dilute most chemical spills, but the consequences of not neutralizing acid or alkaline spills, or overdosing such spills with strong acids or bases, can result in chemical burns of plant life, possible increases in the Chemical Oxygen Demand, and resolubilization of heavy metals from a lowering of pH.

For suppliers of sodium bicarbonate and sodium dihydrogen phosphate, consult manufacturers directories such as the annual Chemical Week Buyer's Guide, Fraser's Canadian Trade Directory, or Thomas Register of American Manufacturers ("Thomcat" directory).

E Photochemical Oxidation/Reduction(1, 2, 6, 7)

See also Entries No. 141 and 146.

Ultraviolet light can be utilized either in combination with ozone to oxidize organics or in a reducing environment to dehalogenate chlorinated, brominated or iodinated organics. The UV/ozonation process requires on-site ozone generation with some residual release; the percent destruction would generally be limited by ozone supply capacity. The process is not suitable for concentrated wastes high in organics or suspended solids. Skid-mounted packages have been developed which illustrate, to some extent, features appropriate for the control of hazardous material spills. These include compactness, quick startup and shutdown, unskilled operator operation, ready maintenance, and self-contained power plant. UV and ozone have been used to oxidize such substances as refractory and toxic chemicals, organometallic complexes and reduced inorganics.

UV light is also used in the Light Activated Reduction of Chemicals (LARC)(6) process in combination with hydrogen gas. The approach is described in greater detail in Entry No. 141.

Briefly, it entails the use of UV to initiate a photochemical process by cleaving, for example, the carbon-chlorine bond in a PCB molecule. In the presence of the hydrogen gas, a carbon-hydrogen bond forms; degradation products include biphenyl and hydrogen chloride (when chlorinated organics are involved) which can be removed by distillation.

LARC dehalogenation reactions are normally conducted in a basic water, alcohol or hydrocarbon solvent. For decontamination of soils, a light-weight alcohol, basic water or hydrocarbon solvent can be used for the extraction. Once neutralized, the decontaminated soil can be returned to the environment.

A mobile unit for the destruction of PCBs in soil has been proposed which is based on the LARC process. The system is reported to entail lower costs than comparable spill response systems utilizing landfilling techniques for the contaminated soil. Its design would be predicated on pilot plants constructed to investigate the use of single and multiple UV lamps, the wavelength of light employed, temperature effects, increases in hydrogen flow and turbulence.

2.8.2 Physical wastewater treatment

F Carbon Adsorption

Many organic, and some inorganic, molecules in solution can attach themselves through attractive forces to the solid surface of activated carbon until equilibrium is established with the concentration in solution. The adsorbing carbon is produced from cellulosic materials such as wood, coal, peat and lignin which have undergone dehydration and carbonization. Pore openings are then enlarged by activation to increase the surface area and therefore the adsorptive capacity.

Carbon adsorption depends upon the molecular size, structure, solubility and polarity of the material being adsorbed; the type of carbon; pH of the solution; and carbon contact time. Generally, the rate of adsorption increases with increasing temperature and decreasing concentrations (1000 mg/L soluble contaminant or greater requires excessive detention times and produces large amounts of spent carbon). An indication of chemical applicability(7) is as follows:

Selected Organics Removed by Activated Carbon

Compound	Carbon capacity (mg/g)*	Compound	Carbon capacity (mg/g)*
Hexachlorobutadiene	360	1,2,3,4-Tetrahydronaphthalene	74
Anethole	300	Adenine	71
Phenyl Mercuric Acetate	270	Nitrobenzene	68
p-Nonyl Phenol	250	Dibromochloromethane	63
Acridine Yellow	230	Ethyl Benzene	53
Benzidine Dihydrochloride	220	o-Anisidine	50
n-Butyl Phthalate	200†	5-Bromouracil	44
N-Nitrosodiphenylamine	220	Carbon Tetrachloride	40
Dimethylphenyl Carbinol	210	Ethylene Chloride	36
Bromoform	200	2,4-Dinitrophenol	33
B-Naphthol	100	Thymine	27
Acridine Orange	180	5-Chlorouracil	25
a-Naphthol	180	Phenol	21
a-Naphthylamine	160	Trichloroethylene	21
Pentachlorophenol	150	Adipic Acid	20†
p-Nitroaniline	140	Bromodichloromethane	19
1-Chloro-2-Nitrobenzene	130	bis-2-Chloroethyl Ether	11
Benzothiazole	120	Chloroform	11
Diphenylamine	120	Uracil	11
Guanine	120	Cyclohexanone	6.2
Styrene	120	5-Fluorouracil	5.5
Dimethyl Phthalate	97	Cytosine	1.1
Chlorobenzene	93	Ethylenediaminetetraacetic Acid	0.86
Hydroquinone	90	Benzoic Acid	0.80
p-Xylene	85	Benzene	0.70
Acetophenone	74		

* Capacity at C_0 = 1 mg/L; milligrams of chemical adsorbed per gram of carbon
† Adsorption capacities at pH 3.

Examples of Chemicals Not Adsorbed by Activated Carbon

1. Acetone cyanohydrin
2. Butylamine
3. Choline chloride
4. Cyclohexylamine
5. Diethylene glycol
6. Ethylenediamine
7. Hexamethylenediamine
8. Morpholine
9. Triethanolamine

Once the capacity of the carbon to remove a substance has been exhausted, the spent carbon must be replaced, disposed of and/or regenerated for reuse. Thermal regeneration is most commonly employed; it is a technique that is possible in the field with some mobile systems.

The removal of spilled hazardous materials using powdered or granular carbon usually consists of external treatment through carbon columns or beds brought to the site. See also Entries No. 57, 58 and 62. Sometimes a laboratory batch test is necessary to define carbon effectiveness when its applicability to the released substance is unknown. Other considerations when utilizing carbon adsorption methods for spill response include(1,7):

(1) Ordering carbon for field use may require 1 to 2 days lead time and an additional 24 hours to wet prior to use.

(2) Wetting carbon results in efficient adsorption. A source of clean water must be available on site prior to startup.

(3) Adsorptive capacity of a carbon bed is reached at "breakthrough". Curves can be prepared illustrating termination of the cycle (breakthrough) so that spent carbon can be replaced and other columns used (assuming a multiple column system in series).

(4) Use of a carbon column as a filter results in inefficient use of its adsorption capabilities. Clarification is usually a necessary pretreatment step prior to carbon adsorption.

(5) Bed stratification (through initial backwash), good flow distribution and an underdrain system (to prevent carbon from exiting with effluent) increase the efficacy of carbon adsorption.

Other forms of carbon such as "tea bags", other packaging concepts, and carbon broadcast on water in powdered form have also been tried as means of in-situ treatment of spilled materials, but generally exhibit lower capacity than larger multiple column systems (see Entry No. 58).

G Ion Exchange(1, 2, 4, 7)

This process involves the exchange of toxic or undesirable ions in wastewater for relatively harmless ions such as H^+, OH^-, Na^+, held by electrostatic forces to functional groups on the surface of a solid ion exchange material. The material is usually a synthetic organic resin that can be a weakly or strongly acidic cationic exchanger or basic anion exchanger. Natural substances such as zeolite, clay and protein have also been used. More recently, sorptive resins have been developed which are capable of removing organics from aqueous systems by sorption rather than ion exchange. Resin regeneration consists of "elution" of the adsorbed material with an organic solvent or inorganic salt solution. Concurrent and countercurrent fixed bed as well as continuous countercurrent ion exchange systems are in use today.

Ion exchange is applied to water softening, boiler water treatment and material recovery and/or treatment of effluent from electroplating and munitions plants. Ion exchange is also effective in removing fertilizers, dyestuffs, pesticides, chlorine and resins, recovering phenol from 20% brine, and removal of colour and organics from pulp mill waste.

Pretreatment for suspended solids removal may be necessary for longer service. Frequent resin regeneration may also be required for very concentrated waste. The residue produced then must be treated further or disposed of, but this seldom exceeds 10% by volume of the influent.

Trailer-mounted units have been used on a pilot-plant scale in field studies involving the processing of biologically-treated sewage and wastewaters at a munitions plant and at a naval installation. Overall, there are many desirable features which make the approach promising for hazardous material spill response. These include the design potential for compact, modular units, quick startup and shutdown, convenient servicing, unskilled operator operation and ease of automation. Ion exchange is applicable to a range of waste types and concentrations including those having low or high pH and oxidizing chemicals if resin types, system design, and operation are optimumly selected.

Major developers/suppliers located in the U.S.A. and Canada:
Chemical Separation Corp.
Oak Ridge, TN, U.S.A.

Crane Co.
King of Prussia, PA, U.S.A.

Dow Chemical
Midland, MI
Sarnia, Ontario, Canada

Ecodyne
Union, NJ, U.S.A.

Illinois Water Treatment
Rockford, IL, U.S.A.

Infilco
Richmond, VA, U.S.A.

Permutit
Paramus, NJ, U.S.A.

Rohm and Haas
Philadelphia, PA, U.S.A.
Westhill, Ontario, Canada

H Precipitation, Flocculation and Sedimentation

Precipitation, flocculation and sedimentation represent a common sequence for treating industrial and municipal wastewaters. Precipitation transforms a substance in solution into small (colloidal) solid particles. Flocculation agglomerates these particles into larger suspended solids which can then be separated from the water by gravity sedimentation.

Precipitation. Primarily, inorganic ionic species (e.g., metals) are treated using precipitation. Three classes of such compounds are(1):

1) Divalent Metals forming insoluble products with a variety of anions (cadmium chloride, copper sulphate, ferrous sulphate, nickel sulphate, zinc chloride).

2) High Valency Metals (antimony trifluoride, silver nitrate, titanium tetrachloride).

3) Oxyanions subject to redox reactions and subsequent precipitation (potassium dichromate, potassium permanganate).

Most precipitation reactions are induced by one or a combination of the following mechanisms:

- Adding a compound which readily reacts with the substance to be precipitated to form a sparingly soluble compound, e.g., add sodium sulphide (Na_2S) to zinc chloride ($ZnCl_2$) to precipitate zinc sulphide (ZnS).

- Adding a substance that will shift the solubility equilibrium of the dissolved waste such that an unstable unsaturated solution is formed, e.g., add hydroxide (OH^-) to a solution of ferrous ions (Fe^{++}) such that Fe (OH_2) precipitates as a solid.

- Changing the temperature of a saturated or nearly saturated solution to decrease stability. This technique has very limited application for waste treatment because the solubility of the sparingly soluble precipitates is a weak function of temperature(2).

Flocculation. Flocculation and coagulation are both terms describing the mechanism of agglomerating suspended particles into larger particles. No precise definitions have been accepted which differentiate the two terms. Flocculation is adopted here since most manufacturers market coagulants as flocculating agents.

The mechanism of flocculation comprises two sequential mechanisms:

1) Repulsive surface forces are chemically destabilized so that particles will stick together when they touch.

2) Chemical bridging between nonrepelling particles allows larger particles to form.

Commonly used inorganic flocculants include alum, ferric chloride and lime. In the case of alum, for example, fluffy, gelatinous 'floc' of aluminum hydroxide is formed upon mixing with wastewater. This floc enmeshes smaller particles due to its large surface area and thereby creates larger particles. Ferric chloride is effective in clarifying both organic and inorganic suspensions. Dilute suspensions require dosages of approximately 50 to 500 mg/L, although larger dosages may be required for concentrated or highly alkaline suspensions. (The pH should be above 6 for best results.) Excessive doses of ferric chloride will result in a brown-coloured effluent and should be avoided.

Alum (aluminum sulphate) is effective in clarifying both organic and inorganic suspensions. The pH should be controlled in the range of 6.5 to 7.5. Alum dosages of 100 to 1000 mg/L should be effective for dilute suspensions. As with ferric chloride, suspensions low in alkalinity may require an addition of lime or caustic to produce the final pH range of 6.5 to 7.5(1).

Potential candidates for precipitants, in order of decreasing effectiveness (8) are: metal sulphides, phosphates, hydroxide, carbonate and oxalate. Of the sulphides, hydrogen sulphide and sodium sulphide are not recommended. Hydrogen sulphide is a toxic gas and the strong basicity of sodium sulphide (similar to sodium hydroxide) would produce a pH outside the acceptable range of 6 to 9 if misapplied.

Dibasic sodium phosphate is a preferred phosphate precipitant, widely used in wastewater treatment and in the food industry. It is not effective against soluble chromium or manganese compounds, spills of which could be treated by sodium sulphite or ferrous sulphate.

More recently developed flocculants are organic polyelectrolytes consisting of long-chain, water-soluble polymers, such as polyacrylamides. They are available in anionic, cationic or nonionic form and may be effective alone when flocculating suspensions of inorganic materials (clay, soils, colloidals, metal salts, etc.). These polyelectrolytes are usually not effective alone when flocculating organic suspension, but can be used with alum or ferric chloride for treating organic suspensions. Dosages vary with both the type of charge on the polymer and the type of suspension to be treated. Cationic polyelectrolytes are generally added in higher dosages, 1 to 10 mg/L in dilute situations (less than 100 mg/L suspended solids) and anionic or nonionic polymers are added at approximately 0.5 to 5 mg/L. When the solution is concentrated and the suspended solids concentration is greater than 1000 mg/L, add 1 to 300 mg/L of a cationic polyelectrolyte or 1 to 100 mg/L or an anionic or nonionic compound(1).

Some manufacturers of polyelectrolytes include Betz, Celanese, Cyanamid, and Rohm and Haas.

Sedimentation. Precipitation and flocculation are employed to improve the final separation of hazardous chemicals from wastewater (i.e., gravity sedimentation). Settling basins or ponds and clarifiers (usually circular) are the most common equipment used for sedimentation. Precipitants and flocculants are best applied to wastewaters in such controlled systems rather than in-situ (i.e., in flowing streams) because settled solids are most effectively removed, reducing the opportunity for wastes, especially metals, to redissolve into solution. The U.S. Environmental Protection Agency has incorporated sedimentation into a number of mobile wastewater treatment units. See the following entries in this survey for further explanation of such systems:

	Entry No.
EPA Mobile Physical/Chemical Treatment Trailers	69
EPA Mobile Flocculation - Sedimentation System	68
EPA/Met-Pro Mobile Independent Physical/Chemical Wastewater Treatment System	67

Consult also directories of manufacturers such as Fraser's Canadian Trade Directory, Thomas Register of American Manufacturers ("Thomcat" directory) or the annual Chemical Week Buyer's Guide, under "Water Treatment (Chemicals)" for suppliers of precipitants and flocculants.

I Reverse Osmosis(2, 10)

See also Entry No. 71.

In reverse osmosis, high pressure is used to force a solvent to flow from a concentrated solution through a membrane permeable to the solvent but not to the solute. The result is that a "permeate" can be produced low in dissolved solids along with "reject" (i.e., a concentrated waste), which because of its relatively small volume can be readily disposed, treated or subjected to material recovery. This concentrating effect whereby chemicals can be effectively removed from a solvent, such as water, has positive implications for the cleanup of hazardous material spills. In particular, newly developed membranes have taken the technology beyond its original primary use of the desalination of salt and brackish waters as more chemically-resistant materials have emerged. These are capable of excluding smaller molecules.

The original membranes of cellulose acetate followed by its replacement cellulose triacetate have given way to thin-film composites utilizing combinations of polyamides, polyimides, polyethers, polyesters and/or polysulphones. These are now constructed in three main configurations including spiral wound, hollow fibre, and tubular, each with its own advantages and disadvantages but all aimed at optimizing the RO process. Specifically, past problems associated with membranes are being researched including fouling and degradation by suspended solids, biological growth, strong oxidizers, very low or high pH and high concentrations of specific substances such as phenols, calcium, silica, sulphate and aluminum.

For spill application, compact trailer-mounted units have been constructed in Canada(10) and the U.S. These are based on RO technology used for the treatment of various industrial wastewaters and in the processing of chemicals, foodstuffs, etc. Features of such equipment which make it particularly suitable for cleanup include the choice of membranes now available, quick on-line and shutdown capability, ease of operation, ready maintenance characteristics, small residue volume, and self-contained power (diesel) design. Evaluation of membranes by or on behalf of Environment Canada should ultimately result in hardware with higher capacities and applicability to a broader range of chemicals of concern.

J Solvent Extraction

Solvent extraction is the process of contacting an immiscible solvent with an aqueous solution so that hazardous materials in the aqueous solution are transferred to the solvent phase. The solvent is generally purified and reused.

The use of solvent extraction in hazardous material spill cleanup is limited by equipment size and operation, the compatibility of hazardous materials with appropriate solvents, and the environmental impact of the solvent itself. However, solvent extraction does offer the possibility of recovery and reuse of hazardous materials from large volume spills, an advantage similar to reverse osmosis.

Multistage extractors are generally used rather than single-stage solvent extractors because higher recovery rates can be achieved. A five-stage extractor (considered the practical limit of most equipment(2)) could recover over 95% of a hazardous material if the partition coefficient is greater than or equal to one. (The partition coefficient is defined as the weight fraction of chemical in the solvent divided by the weight fraction in the aqueous solution (Ws/Ww).) However, multistage systems require more complex process control for efficient operation.

Interfacial tension and contact, and density differences between the aqueous phase and solvent are the primary factors affecting the mass transfer rate of a chemical between phases. Interfacial contact can be controlled by mixing, and interfacial tension by additives such as surfactants. Interfacial tension is sensitive to impurities (e.g., dissolved metals or organics) in both phases. The lower the density difference between phases, the higher the interfacial tension must be to achieve adequate separation.

Four organic solvents have been identified for extraction of spilled organics: vegetable oils, heptane, octanol and oleyl alcohol(9). Vegetable oils are the preferred solvent primarily because of their low toxicity (if leaked from the process to the environment), low fire hazard and safe handling (e.g., soyabean oil flashpoint is approximately 280°C), relatively high interfacial tension, and availability in bulk.

Of the following list of chemicals studied by Drake et al.(1), about 20% were extractable with vegetable oil (designated (T), i.e., partition coefficients greater than or equal to one). Chemicals designated as no treatment required (NT) are based on their low toxicity and therefore treated by natural dilution and dispersion. NX denotes chemicals which cannot be extracted by vegetable oil and ND means no data were available.

Chemicals Subject to Solvent Extraction

Chemical	Comments
Acetone Cyanohydrin	NX
Allyl Alcohol	NX
Aminoethanolamine	NT
n-Amyl Alcohol	T
1,4-Butenediol	NX
n-Butyl Acetate	T
n-Butyl Alcohol	T
sec-Butyl Alcohol	NT
tert-Butyl Alcohol	NT
1,4-Butynediol	NX
Carbon Bisulphide	T
Chloroform	T
Chlorohydrins (crude)	NX
Corn Syrup	NT
Dextrose Solution	NT
Diacetone Alcohol	NT
Dichloromethane	T
Diethanolamine	NT
Diethylene Glycol	NT
Diethylene Glycol Dimethyl Ether	NX
Diethylene Glycol Monoethyl Ether	NX
Diethylene Glycol Monomethyl Ether	NX
Diisopropanolamine	NX
Dimethylsulphate	ND
Dimethylsulphoxide	NT
1,4-Dioxane	NX
Dipropylene Glycol	ND
Epichlorohydrin	ND
Ethoxytriglycol	NT
Ethoxylated Dodecanol	NT
Ethoxylated Pentadecanol	NT
Ethoxylated Tetradecanol	NT
Ethoxylated Tridecanol	NT
Ethyl Acetate	T
Ethyl Acrylate	ND
Ethyl Alcohol	NT
Ethylene Cyanohydrin	NX
Ethylene Glycol	NT
Ethylene Glycol Monobutyl-ether	NX
Ethylene Glycol Monoethyl ether	NX
Ethylene Glycol Monomethyl ether acetate	NX
Ethylene Glycol Monomethyl ether	NX
Ethyleneimine (Monoethanolamine)	NX
Formaldehyde Solution	T

Chemicals Subject to Solvent Extraction (Cont'd)

Chemical	Comments
Glycerine	NT
Hexylene Glycol	NX
Isoamyl Alcohol	T
Isobutyl Alcohol	NT
Isopropyl Acetate	NT
Isopropyl Alcohol	NX
Methanearsonic Acid, Sodium Salts	ND
Methyl Acrylate	T
Methyl Alcohol	NT
Methyl Amyl Alcohol	T
Methyl Isobutyl Carbinol	T
Methyl Methacrylate	T
Monoethanolamine	NT
Monoisopropanolamine	NT
Morpholine	ND
Paraformaldehyde	T
Polypropylene Glycol Methyl Ether	NX
n-Propyl Acetate	T
n-Propyl Alcohol	NX
Propylene Glycol	NT
Propylene Glycol Methyl Ether	NX
Propylene Oxide	NT
Sodium Alkylbenzene Sulphonates	T
Sodium Alkyl Sulphates	T
Sorbitol	NT
Sulpholane	ND
Tetrahydrofuran	ND
Triethanolamine	NX
Triethylene Glycol	NT
Vinyl Acetate	T

Solvent extraction has been employed in soil cleaning systems. Refer to Entry No. 33 "EPA Solvent Extraction System" for further discussion of the performance and operation of such systems.

K Ultrafiltration

Dilute products can be concentrated or certain chemicals recovered from waste streams by a pressure-driven membrane separation process, operating at a lower pressure than reverse osmosis, known as Ultrafiltration (UF). The technique is better suited to deal with large molecular weight substances such as Kraft black liquor, cheese whey and dye rinses. In some cases, ultrafiltration can be interchanged with reverse osmosis using the same basic hardware packaged to increase the versatility of treatment capability. See also Entries No. 70 and 71.

Generally, UF membranes feature pores covering a size range of 10^{-3} to 10^{-2} microns and operate at a pressure of 0.18 to 1.1 MPa (as compared to 2.6 to 4.2 MPa for reverse osmosis). Lower operating pressures are possible because UF membranes are microporous. The osmotic pressure of the materials retained by UF membranes is therefore so low that it does not significantly influence the solvent flux. In comparison, RO membranes are nonporous diffusion barriers.

The separation characteristics of UF membranes are determined by their porosity and thickness as well as by system variables such as pressure, temperature, feed velocity and waste composition. Organic polymers such as cellulose acetate or inorganics such as zirconium oxide are used to fabricate the semipermeable membranes.

Common configurations are tubular, spiral wound and hollow fiber. These can be custom-fabricated in terms of porosity for the separation of specific molecular weights between 500 and 500 000. (Solute molecules should be at least one to two orders of magnitude larger than solvent molecules.)

To date, almost all commercial uses of the ultrafiltration process have been in industrial applications. A notable exception is the Memtek Corporation device (Entry No. 71)(10) which was developed to deal with spills of hazardous materials. The machine typifies the potential for UF/RO in spill response because it is compact, mobile, easy to maintain and operate, and is a self-contained unit (with the exception of storage). Membrane fouling and degradation is reported to be similar to reverse osmosis albeit to a lesser extent. Also, for wastes containing high levels of low molecular weight substances, additional treatment of effluent may be required.

L Wet Air Oxidation

High strength or toxic organics, and wastes containing significant concentrations of non-biodegradable organic matter, can be treated by wet air oxidation. The process involves the aqueous phase oxidation of reduced inorganics and organics with air at high temperatures (200 to 300°C) and pressures 1 to 29 MPa) to innoccuous inorganic end-products (e.g., CO_2, H_2O, $SO_4^{=}$, etc.). Two main advantages are the absence of air pollution problems vis-à-vis conventional combustion processes and the lack of waste pretreatment required such as sludge dewatering or drying. Details of the equipment used in various Wetox systems are given in four separate entries (No. 139, 142, 149 and No. 150).

While Wetox can achieve very high destruction efficiencies of suspended solid organics, general limitations to spill response relate to the size and weight of equipment suitable for trailer mounting. Currently, mobile (skid-mounted) units capable of processing 38 L/min are amongst the largest available in the U.S. In Canada, work on a mobile system has been halted at present in spite of earlier promising results. A further limitation, albeit less critical, is the necessity of supplementary heating in the case of low BTU wastes. The technology also requires skilled operators, especially for hazardous wastes as well as special design and construction materials. Of several hundred units in operation worldwide, the majority of these are used in processing municipal sludges.

References

1. Hazardous Chemical Spill Cleanup, edited by J.S. Robinson, Noyes Data Corporation: Park Ridge, NJ (1979).

2. Ghassemi, M. et al., Feasibility of Commercialized Water Treatment Techniques for Concentrated Waste Spills, U.S. Environmental Protection Agency, Report EPA-600/2-81-213 (NTIS No. PB82-108440) (September, 1981).

3. Huibregtse, K.R. et al., (Envrix Inc.), Manual for the Control of Hazardous Material Spills: Volume 1 - Spill Assessment and Water Treatment Techniques, U.S. Environmental Protection Agency, Report EPA-600/2-77-227 (November, 1977).

4. Kiang, Yen-Hsiung and A.A. Metry, Hazardous Waste Processing Technology, Ann Arbor Science Publishers, Inc., Collingwood, MI (1982).

5. Drake, E. et al., A Feasibility Study of Response Techniques for Discharges of Hazardous Chemicals that Disperse through the Water Column, U.S. Coast Guard, Report No. CG-D-16-77 (July, 1976).

6. Kitchens, J.F., G.L. Anspach, L.B. Mangoba, and E.A. Kobylinski, "Cleanup of Spilled Chlorinated Organics with the LARC Process", Proceedings of the 1984 Hazardous Materials Spills Conference, Nashville, TN (April 9-12, 1984).

7. Bennett, G.F., F.S. Feates, and I. Wilder, Hazardous Materials Spills Handbook, McGraw-Hill Book Company, U.S.A. (1982).

8. FMC Corporation, Industrial Chemical Group, Manual for "Industrial Waste Treatment with Hydrogen Peroxide".

9. Lyman, W.J., D. Shooter, and J.R. Sinclair, "Treatment Techniques for Spills of Hazardous Water Soluble Chemicals - A Feasibility Study", Journal of Hazardous Materials, No. 5, pp. 131-143 (1981). (Presented at the 1980 Conference on the Control of Hazardous Materials Spills, Louisville, Kentucky.)

10. Whittaker, H. and O.V. Nowakiwsky, "Reverse Osmosis in Chemical Spill Control", Proceedings of the Technical Seminar on Chemical Spills, Environment Canada, Toronto, Ontario (October 25-27, 1983).

3 TEMPORARY STORAGE

3 TEMPORARY STORAGE

3.1 Flexible Containers

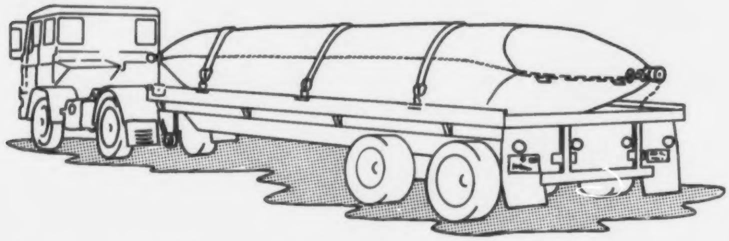
PRODUCT FLEXIBLE TANKS - GENERAL LISTING **No. 81**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

Note: Some systems may be suitable for the temporary storage of solids although these are in a minority.

DESCRIPTION – Various flexible or collapsible containers designed for storing and/or transporting chemicals, hazardous materials and petroleum products. These range from bladders intended for on-land or in-water usage to open-top flexible reservoirs. Both portable devices and those intended for stationary set-up are marketed with minimal space requirements the most notable highlight when these systems are either being stored or transported.



OPERATING PRINCIPLE – Most flexible bladders, pillow tanks or other collapsible containers have been developed to hold liquids. Fully enclosed models feature an inlet port; may also include an air vent, separate discharge opening and hardware to effect direct coupling with pumps used to transfer the liquids of concern. Durable construction permits their set-up in or transportation to remote areas.

PHYSICAL SPECIFICATIONS – These vary from company to company and model to model. Open-top tanks generally range in capacity from 1000 L (264 U.S. gal) up to 75 708 L (20 000 U.S. gal), weigh 20 to 400 kg (44 to 882 lb), and when full can occupy a space up to approximately 9 x 9 x 1.5 m (29.5 x 29.5 x 5 ft).

Materials of construction also vary and include: PVC-coated polyester or nylon substrate; Neoprene and Hyplon reinforced with nylon; Two-ply urethane-coated nylon (Shelterite); and PVC-coated polyamid.

Others include reinforcement of polypropylene and polyester with coatings of nitrile, butyl, chlorinated polyethylene and various hybrids.

OPERATING SPECIFICATIONS – Chemical compatibility should be determined through manufacturers as well as fill and discharge procedures, suitable operating temperatures, storage requirements, size of fittings and expected life span. Conditions of use including lifting hardware, protective ground covers, U.V. shields and other accessories should also be determined.

STATUS OF DEVELOPMENT AND USAGE – Commercial products generally available with expected usage for hazardous materials indicated or readily ascertained. Patented ideas and prototypes are also discussed in more detail in separate entries this section.

PERFORMANCE – Evaluation data were not obtained. Many systems are available that would appear to have application to the cleanup of hazardous material spills. The use of flexible containers provides quick but substantial liquid storage volume, ease of handling prior to fill-up, isolation of the contaminant from the surrounding environment and, with proper planning, facilitation of transportation to ultimate disposal facilities.

AVAILABILITY AND COMMERCIAL INFORMATION – Several representative manufacturers have been selected and brief comments made on their products. These are presented in alphabetical order:

Manufacturer	Product(s)	Comments
Aero Tec Laboratories, Inc. Spear Road Industrial Park Ramsey, NJ 07446 U.S.A. Telephone (201) 825-1400 Telex 642730 ab ATLINC	Petro-Flex and Chem-Flex pillow tanks. Cargo-Flex tanks, Topless tank, Drop drum.	A wide range of flexible containers for chemical storage and transport.
Alsthom Atlantic, Inc. Contact: Response Systems, Inc. 820 Ritchie Highway Severna Park, MD 21146 U.S.A. Telephone (301) 647-4424 Contact: Mr. Ken Wehmueller	Diodon flexible tanks	Designed for oil; are compatible with a variety of hazardous materials. See separate entry this section.
British Hovercraft Corporation East Cowes Isle of Wright England Telephone Cowes 4101 Telex 86761	Flexible pillow tanks	Designed for holding a range of chemicals including waste substances.
Dunlop Limited G.R.G. Division Pimbo Industrial Estate Skelmersdale, Lancashire WN8 9PW England Telephone 0695 24111 Telex 627107	Dracone barges and collapsible containers	Dracones designed as floating flexible tanks for oil. Other Dunlop collapsible containers designed to hold chemicals.
Kleber Marston Products 6, Avenue Kleber 75784 Paris Cedex 16 France Telephone 553-01-00 Telex 26811	Flexible tanks	Designed for the on-land storage of a wide range of chemicals and oils.
Kepner Plastics Fabricators, Inc. 3131 Lomita Boulevard Torrance, CA 90505 U.S.A. Telephone (213) 325-3162 Telex 691646	Seacontainer flexible containers	Towable oil containment bag up to 375 000 L (99 065 U.S. gal) Consult manufacturer for chemical compatibility.
Skimmex Ltd. 270 Earls Court Road London SW5 9AD England Telephone 01-3703315 Telex 918986 ab FISHG	Skimmex temporary storage containers	Consult manufacturer for compatibility with other petroleum products.
Transtech Container System Co. Ltd. 3265 South Milway Townhouse 3 Mississauga, Ont. L5L 2R3 Canada Telephone (416) 828-0859 Contact: Mr. Ray Farren	Transtech liquid container	Rigid frame holds a flexible bag of 2 680 L (708 U.S. gal) capacity. Should be compatible with many chemicals although designed for oil. Consult manufacturer.

Manufacturer	Product(s)	Comments
Trelleborg AB Protective Products Division P.O. Box 501 S-23101 Trelleborg Sweden Telephone (46) 410 51 000 Telex 32948	Trellcone floating container	Towable bags of 10,25 and 50 m^3 (353 883 and 1766 ft^3) storage. Consult manufacturer for chemical compatibility.
Uniroyal, Inc. Engineered Systems 312 North Hill Street Mishawaka, IN 46544 U.S.A. Telephone (219) 255-2181	Sealed tank, Sealed bin and other collapsible containers	A comprehensive line of flexible tanks and drums intended for storing and transporting chemicals.
MSA Research Corporation Evans City, PA 16033 U.S.A. Telephone (412) 538-3510 Contact: Mr. Ralph Hiltz	Portable collection bag system	Conceived specifically for storing hazardous materials. See separate entry this section.
Oil Recovery International Truckton Bridge Christchurch Dorset BH23 1JS England Telephone 02015 6666 Telex 41354 ab OILMOP G	Floating oil storage tanks	Flexible containers which can be towed. Consult manufacturer for chemical compatibility.
Pronal SA 139 Rue des Arts BP 19-59051 Roubaix France Telephone (20) 70 0710 Telex 120750	Flexible tanks	One to 300 m^3 (10 594 ft^3) tanks designed for the storage of chemicals, oils, foodstuffs and water.
Soper's Engineered Fabric Products P.O. Box 277 Chatham Street Hamilton, Ont. Canada L8N 3E8	Port-a-tank folding storage tanks	A frame supports an open-top reservoir. See separate entry this section.
Versatech Products Incorporated 60 Riverside Drive North Vancouver, B.C. V7H 1T4 Canada Telephone (604) 929-5451 Telex 043-52686 ab VERSTECH VCR	Oil storage containers	Closed and open top flexible containers designed for oil. Consult manufacturer for compatibility with chemicals.

OTHER DATA – Industrial registers and telephone directories should be referenced for other manufacturers. Chemical resistance of many materials should render many flexible containers suitable for use on hazardous material spills; however, this aspect should be predetermined. Storage and transportation modes as well as longevity should also be determined.

PRODUCT DIODON FLEXIBLE TANK **No. 82**

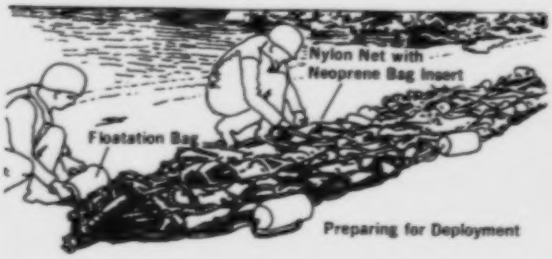
APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
		*				

May have application to other liquids depending on circumstances.

DESCRIPTION – A floating flexible tank for temporary storage of hazardous materials from cleanup of marine pollution. The tank is comprised of neoprene-coated material contained in a nylon net fitted with a towing system. It has a filling hose at one end, quick connection hardware, and a single valve. At the other end of the tank is a quick opening valve of larger diameter.

A Transportation Mode



Nylon Net with Neoprene Bag Insert
Floatation Bag

Preparing for Deployment

OPERATING PRINCIPLE – The nylon net provides reinforcement to the flexible bag so that it can be towed in water or lifted by helicopter or crane; it also acts as a fender to protect the bag. The tank can be emptied by pumping from the single valve or by gravity drainage through the quick opening valve.

PHYSICAL SPECIFICATIONS –

Available in 4, 10 and 20 m^3 (140 350 and 700 ft^3) capacities

Dimensions and weight:

Capacity m^3 (ft^3)	4 (140)	10 (350)	20 (700)
Diameter m (ft)	0.9 (3)	1.8 (6)	2.25 (7.4)
Length m (ft)	6.3 (20.6)	4.5 (15)	5.8 (19)
Weight kg (lb)	30 (66)	110 (240)	150 (330)

Filling hose 51 mm (2 in) dia.
Outlet valve 305 mm (1 ft) dia.
Tow net 12 mm (0.5 in) dia.
Resistance of bag 1.4 kg/mm^2
Materials of construction - neoprene and Hypalon reinforced with nylon; exterior polypropylene netting.

OPERATING SPECIFICATIONS –

Towing speed: 9 km/h (5.6 m/h)

Designed for use with oil, but could be used for any chemicals compatible with neoprene.

STATUS OF DEVELOPMENT AND USAGE – Commercially available product used for oil spill cleanup operations. Chemical compatibility should be obtained from manufacturer.

PERFORMANCE – No evaluation data obtained. The reinforced bag combined with exterior netting should facilitate its handling in water-related pollution incidents at remote locations.

AVAILABILITY AND COMMERCIAL INFORMATION –

North American Distributor: Response Systems, Inc.
820 Ritchie Highway
Severna Park, MD 21146
U.S.A.
Telephone (301) 647-4424
Contact: Mr. Ken Wehmueller

OTHER DATA – Diodon tanks were formerly distributed in North America by Alsthom Atlantic, Inc. of New Orleans, LA, U.S.A. who still supply such equipment through their parent company in Grenoble, France to Response Systems, Inc.; personal communication, Mr. K. Wehmueller, 5 June 1984.

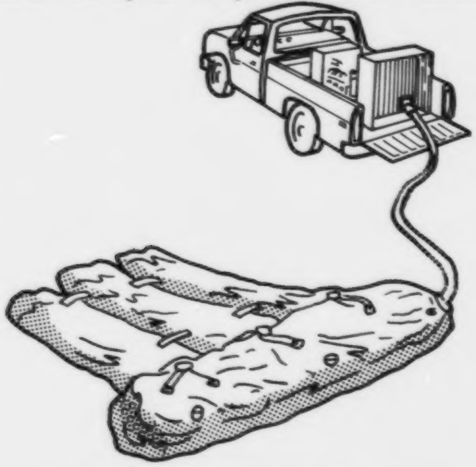
References: Manufacturers' Literature.

PROTOTYPE PORTABLE COLLECTION BAG SYSTEM No. 83

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – Prototype. A unitized pumping and storage unit for the collection and temporary storage of hazardous liquids. The portable unit consists of a collapsible bag, hoses and pump.



OPERATING PRINCIPLE – A pump draws hazardous liquid from up to 30.5 m (100 ft) away to a multi-section storage bag.

PHYSICAL SPECIFICATIONS –

Bags:	One header, three attached reservoirs (four total) Dimensions of each bag 6.1 x 0.9 m (20 x 3 ft) diameter Total Capacity: 26 500 L (7000 U.S. gal) Fabric: Two-ply urethane-coated nylon (Shelter-Rite 7028, 0.8 mm (0.03 in). Colour: White with blue straps, red reflectors on ends of bags.
Pump -	Self-priming centrifugal "ITT Marlow" Model 1 - 1/2 HE 19 EL
Motor -	3 hp explosion-resistant, one cylinder gasoline engine.
Hoses -	Discharge (pump to bags): 15.2 m (50 ft), 38 mm (1.5 in) nominal "Titeflex R276", Teflon/stainless steel construction. Suction: 30.5 m (100 ft) (2 x 15 m) (2 x 49 ft), 51 mm (2 in) I.D., Gates 45 HW Acid-Chemical Transfer Hose. Each section mounted on a separate reel; one is always coupled to the pump.
Valves and Fittings:	All plumbing components are stainless steel except for the basket type inlet strainer which is nickel-plated steel. Couplings are "Evertite".

Storage Size: 1.2 x 1.8 x 1.2 m (4 x 5.5 x 4 ft)

OPERATING SPECIFICATIONS –

Deployable by two people; operated by one person.
Operating Time: approximately 2 hours on 1 U.S. gal of gasoline.
Three-way ball valve permits pumping from either or both of the inlet hoses simultaneously.

Pump Capacity (approximated from performance curve):

L/min (U.S. gal/min)	Head m (ft)
590 (155)	6.1 (20)
470 (125)	12.2 (40)
170 (45)	18.3 (60)

Collection Bags:

Maximum operating incline 30 degrees
Working Pressure 23 kPa (3.3 psi)
Maximum Pressure 39 kPa (5.7 psi)
Burst Pressure 76 kPa (11 psi)
Weight of each bag filled with water 6800 kg (15 000)lb)

STATUS OF DEVELOPMENT AND USAGE – Prototype stage; not a commercially manufactured product.

PERFORMANCE – Tear Strength of Vinyl Fabric After 24 Hours of Exposure to Chemicals.

Chemical	Tear Strength kg (lb)
Phenol	142 (313)
Methyl Alcohol	92 (203)
Acrylonitrile	125 (276)
Benzene	127 (280)
Acetone Cyanhydrin	20 (40)
Xylene	135 (298)
Sulphuric Acid	6 (13)
Aldrin Toxaphene Group	98 (216)
Acetone	115 (254)
Nitric Acid	112 (247)
Ethyl Acetate	101 (223)
Sodium Hydroxide (30% solution)	92 (203)
Methyl Ethyl Ketone (MEK)	89 (196)
Hydrofluoric Acid	89 (196)
Hydrogen Peroxide (30% solution)	101 (223)
n,n-Dimethyl Formamide	119 (262)
Butyl Ether	134 (295)

The collection bag system, mounted on the bed of a 3/4 ton pickup truck, was used to empty water from a tank similar to a tanker truck [26 500 L (7 000 U.S. gal)] and a dyked area surrounding the tank. A 10 minute, narrated, 16-mm colour film of the demonstration was prepared.

AVAILABILITY AND COMMERCIAL INFORMATION – MSAR will supply this prototype equipment as described or with modification on a trial basis, to meet specific needs.

Developed by:

MSA Research Corporation
Evans City, PA 16033
U.S.A.
Telephone (412) 538-3510
Contact: Mr. Ralph H. Hiltz or
Ferdinand Roehlich, Jr.

for:

Industrial Environmental Research Laboratory
Office of Research and Development
U.S. Environmental Protection Agency
Cincinnati, OH 45268
U.S.A.
Dr. John E. Brugger, Project Officer
Report EPA-600/2-77-162, August, 1977
Contract No. 68-03-0206

OTHER DATA – This gas-powered version was developed from an earlier electrically-powered model which is explained in the report referenced below.

This system demonstrated good compatibility with foamed polyurethane diversion barriers. (See the MSAR Dike-Pak System Entry No. 18).

Reference: Hiltz, R.H. and F. Roelich Jr., MSA Research Corporation, Emergency Collection System for Spilled Hazardous Materials, Report EPA-600/2-77-162 (August, 1977).

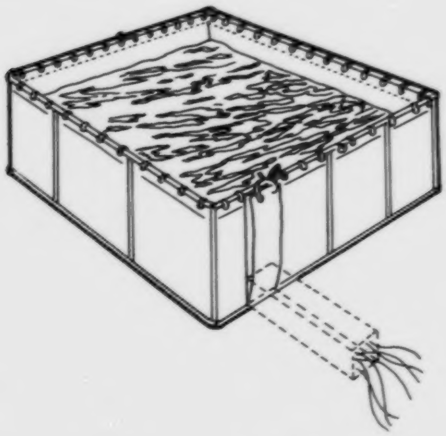
PRODUCT PORT-A-TANK **No. 84**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

Designed primarily for liquids; may have application to solids and particulates depending on circumstances.

DESCRIPTION – A portable, foldable storage reservoir which can be quickly set up without tools.



OPERATING PRINCIPLE – This flexible, open-top tank provides quick, temporary storage for recovered materials.

PHYSICAL SPECIFICATIONS –

Two sizes available:

		1000 Imp. gal (5450 L)	1500 Imp. gal (6820 L)
Size:	(Open)	251 x 249 x 76 cm (99 x 98 x 30 in)	312 x 251 x 76 cm (123 x 99 x 30 in)
	(Closed)	251 x 76 x 25 cm (99 x 30 x 10 in)	312 x 76 x 25 cm (123 x 30 x 10 in)
Total Weight:		63.6 kg (140 lb)	81.7 kg (180 lb)

Frame: 22 mm (7/8 in) OD heavy gauge tubular steel with welded joints and hinges; baked enamel finish.

Liner: Choice of

Reinforced Vinyl	No. 10 Cotton Duck
0.75 kg/m^2 (22 oz/yd^2) welded seam construction colour: yellow flame and tear resistant will not absorb oil or grease	0.5 kg/m^2 (14.73 oz/yd^2) flame, water and rot-proof double sewn seams rope-reinforced top hem colour: olive drab

OPERATING SPECIFICATIONS – Two persons can open the Port-a-Tank quickly without tools or further assembly.

Fabric tube incorporated with the liner provides quick drainage.

PERFORMANCE – Although documentation was not received on the application of Port-a-tanks to hazardous material spills, they are known to have been used frequently during oil spill cleanup operations in Canada.

STATUS OF DEVELOPMENT AND USAGE – In general use by fire departments and oil spill co-operatives across Canada.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Soper's Engineered Fabric Products
P.O. Box 277
Chatham St.
Hamilton, Ontario
L8N 3E8
Canada
Telephone: Hamilton (416) 528-7936
Toronto (416) 362-3758
Kitchener (519) 653-7201
Telex: 061-8306
Contact: Mr. Steven Cox, Technical Sales Consultant

OTHER DATA – Consult manufacturer with regard to choice of fabric liners and their chemical tolerances; special chemical and oil-resistant materials such as Shelterite XR-5 are available.

3.2 Rigid Wall Systems

PRODUCT RIGID WALL TANKS - GENERAL LISTING **No. 85**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*	*	*	*

DESCRIPTION – A very wide variety of tanks are commercially available in materials, ranging from stainless steel to fibreglass. Tank linings or coatings can be specified which are resistant to corrosives and other chemicals. Capacity can also be selected as well as the mode in which the unit is to be used, i.e., indoors, outdoors, fast assembly, free standing, etc. Except for tank trucks, most rigid wall tanks have been conceived for use at fixed facilities although mobile capability based on vehicles with trailers could be readily organized.

OPERATING PRINCIPLE – Rigid wall tanks have been conceived for the storage of both liquid and dry materials. Construction features suitable to holding acids and chemicals can be specified. More recently, a variety of approaches has been attempted to accomplish the following (see other entries this section):

Immobilize toxic substances.
Contain and neutralize spilled materials.
Enclose leaking drums.
Safely transport liquid chemicals.
Store fissile materials.

PHYSICAL SPECIFICATIONS – Consult manufacturer. Size, weight, capacity and anticipated mode of use are the main concerns.

OPERATING SPECIFICATIONS – Consult manufacturer. Chemical compatibility, storage and transportation methods, and other conditions of use (temperature range, assembly time, etc.) are several aspects that might need to be determined.

STATUS OF DEVELOPMENT AND USAGE – Commercially available products that have been used universally with chemicals, acids and other potentially hazardous materials.

PERFORMANCE – Evaluation data were not obtained. Tanks selected of suitable durability, chemical compatibility and configuration should prove useful in isolating a wide variety of spilled hazardous materials from the surrounding environment and in permitting their safe transport to ultimate disposal facilities.

AVAILABILITY AND COMMERCIAL INFORMATION – Refer to industrial registers such as Fraser's Canadian Trade Directory and the U.S. Thomas Register of Products and Services as well as local telephone directories. Listings are numerous.

OTHER DATA – See separate entries this section following this General Listing for patented concepts and other unique products conceived to store and transport hazardous materials.

PRODUCT SALVAGE DRUMS **No. 86**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*	*	*	*

DESCRIPTION – The Basco Dispoz-a-Drum is a corrosion-resistant lined, fully removable head, steel drum used as an overpack shipping container for damaged or leaking drums.

Note: The Basco drum is fully described in this entry. OTHER EQUIVALENT SYSTEMS are more briefly reviewed under Other Data.

OPERATING PRINCIPLE – Fully encloses standard 200 and 215 L (54 and 57 U.S. gal) drums with a rubber gasket sealing cover.

PHYSICAL SPECIFICATIONS –

Common Specifications:

Capacity: 300 L (80 U.S. gal), 0.3044 m^3 (10.75 ft^3)
Outside Dimensions: 68 x 102 cm (27 x 40 in)
Epoxy phenolic coated interior.
Painted hazard warning (yellow).
Printed with DOT "Salvage Drum" logo.
Rubber gasket in removable cover 19 mm (3/4 in) NPT fitting with nylon plug in cover.

	Model 25-16 (Heavy Duty)	Model 24-22 (Light Duty)
Bolted locking ring:	16 Gauge/12 Gauge	22 Gauge/16 Gauge
Inside Dimensions:	64 x 96 cm (25 x 38 in)	61 x 96 cm (24 x 38 in)
Approx. tare wt:	34 kg (75 lb)	18 kg (40 lb)

OPERATING SPECIFICATIONS –

	Model 25-16 (Heavy Duty)	Model 25-22 (Light Duty)
Authorized Usage:		
Steel Drums	DOT 5B, 17C,E,H 37A,B	DOT 37A,B
Steel Composites	DOT 6D, 37M UN/IMCO 6HA1	DOT 37M
Fibre Drums	DOT 21C UN/IMCO 1G1	DOT 21C
Fibre Composites	DOT 21P UN/IMCO 6HG1	DOT 21P
Plastic Drums	DOT 34 (including exemption 55 U.S. gal)	
Bulk	Liquid or dry form hazardous materials mixed with dirt or absorbent medium	

STATUS OF DEVELOPMENT AND USAGE – Commercial product developed specifically to control the leakage of hazardous materials from drums.

PERFORMANCE – No evaluation data obtained; however, use of the drum should facilitate the control of leaking containers as specified.

AVAILABILITY AND COMMERCIAL INFORMATION –

Barrel Accessories & Supply Company (BASCO)
4647 West 47th Street
Chicago, IL 60632
U.S.A.
Telephone (312) 767-8100 or
1-800-621-0621

OTHER DATA – Options available with BASCO drums:

Kit containing
- packet of pressure sensitive hazardous material warning labels,
- marking crayon,
- wrench for opening and closing bolted ring closure,
- large polyethylene bag to shroud damaged or leaking container to be overpacked, and
- 19 mm (3/4 in) NPT red plastic safety vent plug to vent pressure.

109 cm x 157 cm x 0.203 mm (43 x 62 x 0.008 in) round bottom polyethylene liner to provide corrosion protection and permit reuse of drum.

Other Manufacturers of Salvage Drums – The Skolnik Drum Corporation also manufactures heavy duty overpack shipping containers for damaged or leaking drums. Four sizes of salvage drums are available in their Quad-Pak including 322 L (85 U.S. gal), 208 L (55 U.S. gal), 114 L (30 U.S. gal) and 30 L (8 U.S. gal) sizes. Interior options include alkyd resin, epoxy-phenolic or unlined. Individual drums and other sizes are also available all complying with U.S. Department of Transportation requirements.

Manufacturer:

Skolnik Drum Corporation
4601 West 48th Street
Chicago, IL 60632-4896
U.S.A.
Telephone (312) 735-0700
Contact: Mr. Howard Skolnik or
Mr. Daniel Abrahms

Greif Bros. Corporation markets a similar product, the Saf-T-Drum, which is a salvage overpack steel drum. Capacity is 322 L (85 U.S. gal) fabricated in heavy duty (16 gauge), light duty (22 gauge) as well as other specific application gauges of steel. Complying with various U.S. DOT and UN/IMO specifications, the drum can enclose standard 208 L (55 U.S. gal) and 216 L (57 U.S. gal) steel, fibre and plastic drums. The internal surface is coated with epoxy-phenolic lining and the exterior is finished in a hazard-warning yellow colour. For more information, contact:

Greif Bros. Corporation
621 Pennsylvania Avenue
Delaware, OH 43015
U.S.A.
Telephone (614) 363-1271

In Canada, contact:

Greif Containers Inc.
4219 Park Street
Niagara Falls, Ont.
L2E 6S8
Telephone (416) 358-3271

Clearing Container (division of Natico Inc.) markets a Recovery Drum (Model 200) lined with an epoxy-phenolic coating and a Disposal Drum (Model 500) coated inside and out with alkyd resin backed enamel. Both have capacities of 322 L (85 U.S. gal) and accept drums up to 61 cm (24 in) in diameter and 91 cm (36 in) high. For more information, contact:

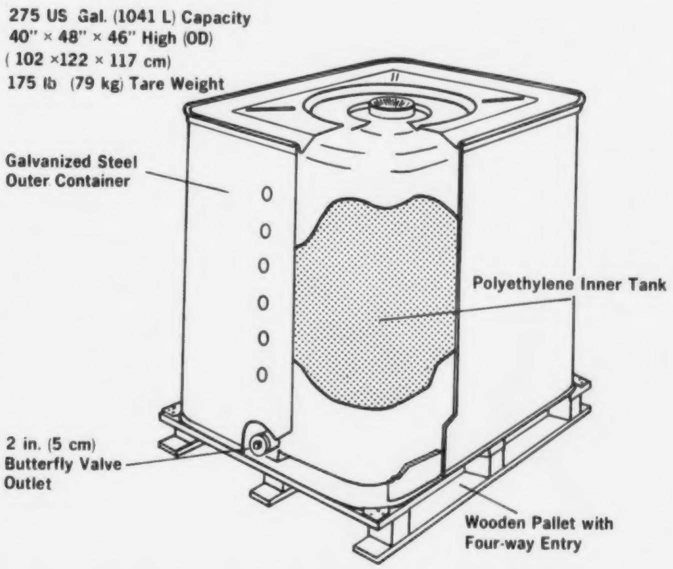
Clearing Container
5100 West 67th Street
Chicago, IL 60638
U.S.A.
Telephone (312) 767-2990

PRODUCT BULKDRUM™ **No. 87**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – A portable bulk-handling container with the capacity of 19-208 L (5-55 U.S. gal) drums for liquid detergents, paints, dyestuffs, petroleum products, pharmaceuticals, foodstuffs, paper chemicals, water treatment, and corrosive chemicals.


275 US Gal. (1041 L) Capacity
40" × 48" × 46" High (OD)
(102 ×122 × 117 cm)
175 lb (79 kg) Tare Weight
Galvanized Steel Outer Container
Polyethylene Inner Tank
2 in. (5 cm) Butterfly Valve Outlet
Wooden Pallet with Four-way Entry

OPERATING PRINCIPLE – An outer steel shell protects an inner plastic tank that is suitable for containing a range of hazardous materials. Unitized pallet, top filling port, bottom discharge outlet and valve, and square shape (which facilitates stacking and side-by-side storage) contribute to increased versatility in bulk handling over conventional methods.

PHYSICAL SPECIFICATIONS –

Materials of Construction:

Inner Tank: Rigid high-density polyethylene

Outer Shell: Galvanized Steel: 24-gauge top and bottom
20-gauge side

Base: Wooden pallet with four-way entry for forklift

Capacity: 1040 L (275 U.S. gal)

Outside Dimensions: 102 x 122 x 117 cm (40 x 48 x 46 in)

Tare Weight: 79.5 kg (175 lb)

Ports: 152 mm (6 in) filling port with optional cap with 51 mm (2 in) Bung plug in centre
51 mm (2 in) butterfly valve outlet and downspout with Vestopren (polyethylene) O-ring (Buna N, Viton and EPDM O-Rings also available)

OTHER DATA – 15 cm (6 in) radii corners to assure thorough discharge

OPERATING SPECIFICATIONS –

Stack three-high (up to 1 818 kg (4 000 lb) gross weight).
Use 20% less space than 55 U.S. gal drums storing the same gallonage.
Fit 46 containers in a 13.7 m (45 ft) trailer.
Acceptable for handling food products as specified under F.D.A. regulation 21 Cfr 177.1520 Olefin Polymers.
Authorized for corrosive liquid transport under U.S. DOT - E8921.
Authorized for Transport of materials prescribed under U.S. DOT - 37M/2LS and DOT - 37M/2U, providing they are compatible with polyethylene.

STATUS OF DEVELOPMENT AND USAGE – Commercial products designed for transporting hazardous, corrosive and other liquid chemicals in bulk.

PERFORMANCE – No evaluation data obtained. Safer storage and transportation, ease of handling and efficient use of space should be several of the advantages of this system of containerization over such methods as conventional drums. Cost and frequency of use might be considerations, however, affecting the decision to purchase this system.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

HOOVER Universal, Inc.
Materials Handling Division
Suite 429, Centrum Center
6363 Poplar Ave.
Memphis, TN 38119
U.S.A.
Telephone (901) 685-6363 or
800-346-2200
Contact: Mr. Pete Hartwig, Regional Sales Manager

Canadian Distributor:

Cassier Engineering Sales, Ltd.
11 Progress Avenue - Unit 3
Scarborough, Ontario
M1P 4S7
Telephone (416) 298-1628
Contact: Mr. Bill O'Brian

OTHER DATA – Hoover also fabricates a variety of other containers suitable for storing and transporting a range of chemical products.

(1) Tote Tanks. These are similar to the Bulkdrum and feature square construction in aluminum, steel and stainless steel with optional liners for corrosive liquids. These are claimed to require 44% less space to store equivalent volumes of drum storage systems and feature unitized pallet construction. Internal heating elements are optional.

Capacity and dimensions are as follows:

ALUMINUM l x w* = 107 x 107 cm (42 x 42 in)		STEEL AND STAINLESS STEEL l x w = 107 x 107 cm (42 x 42 in)	
Capacity L (U.S. gal)	Overall Height cm (in)	Capacity L (U.S. gal)	Overall Height cm (in)
999 (264)	106 (41 3/4)	965 (255)	103 (40 1/2)
1146 (303)	119 (47)	1136 (300)	118 (46 1/2)
1351 (357)	138 (54 1/4)	1306 (345)	133 (52 1/2)
1782 (471)	177 (69 1/2)	1476 (390)	149 (58 1/2)
2176 (575)	212 (83 1/2)	1809 (478)	179 (70 1/2)

ALUMINUM l x w = 107 x 122 cm (42 x 48 in)		STEEL AND STAINLESS STEEL l x w = 107 x 122 cm (42 x 48 in)	
Capacity L (U.S. gal)	Overall Height cm (in)	Capacity L (U.S. gal)	Overall Height cm (in)
1026 (271)	(37 7/8)	1109 (293)	103 (40 1/2)
1151 (304)	106 (41 3/4)	1306 (345)	118 (46 1/2)
1317 (348)	119 (47)	1495 (395)	133 (52 1/2)
1552 (410)	138 (54 1/4)	1688 (446)	149 (58 1/2)
1908 (504)	166 (65 1/4)	2078 (549)	179 (70 1/2)
2498 (660)	212 (83 1/2)		

* L = length
w = width

Tote tanks are also fabricated in high density polyethylene.

(2) Tote Viscotanks. Fabricated in aluminum, steel or stainless, these tanks are available in capacities from 905 L (239 U.S. gal) to 1889 L (499 U.S. gal) and feature flexible polyethylene tank liner which collapses around the fins of a mandril as the contents are pumped out. The container is designed for the transportation of grease, adhesives, caulking compounds, thick paints, etc.

(3) Various Containers. Hoover also manufactures a wide variety of other portable bulk handling products including:

POLY TANK: 1325 L (350 U.S. gal) and 1665 L (440 U.S. gal)
Reuseable and one-way polypropylene/polyethylene bags: 1-ton capacity.
Dry material bins.
Collapsible containers - "Fold-a-Bin".
Fill, discharge, mixing and other specialized containers.

CONCEPT FILTER-LINED CONTAINER FOR RADIOACTIVE MATERIALS No. 88

APPLICABILITY	Gas	Liquid			Solid		
		Sol	Fl	Sk	Sol	Fl	Sk
					*	*	*

DESCRIPTION – Concept. A package in which stored toxic solids are homogeneously dispersed in, and surrounded by, an immobilization material.

OPERATING PRINCIPLE – A bag which is permeable to the immobilization material but not the toxic substance is placed inside a package. The bag is filled with immobilization liquid and the solid toxic substance. Some of the immobilization liquid flows through the bag to fill the space between the bag and the outer package walls. Inside the bag, the liquid and solid mix together. The immobilization liquid subsequently hardens binding the toxic solid inside the bag, and forming a solid barrier (containing no toxic solid) outside the bag.

PHYSICAL SPECIFICATIONS – None obtained.

OPERATING SPECIFICATIONS – Bag smaller than rigid outer package so when the bag is placed inside the package, an empty space is left between the two.

Radioactive substances will remain immobile and impervious to leaching even if outer package is broken.

Packaging method used for long-term storage of solid radioactive wastes.

Bag is made of nylon, cotton, polyethylene, polyester or polypropylene fabric.

STATUS OF DEVELOPMENT AND USAGE – Patented concept with no usage documented.

PERFORMANCE – No evaluation data obtained.

AVAILABILITY AND COMMERCIAL INFORMATION – Commercial production pending.

Aerojet-General Corporation
10300 - TN Torrey Pines Rd.
La Jolla, CA 92037
U.S.A.
Telephone (714) 455-8500

OTHER DATA – This package is a patented invention of Leslie E. White and Charles M. Gracey; patent assigned to the Aerojet-General Corporation, CA.

Reference: U.S. Patent 4 058 479

CONCEPT HAZARD NEUTRALIZING CONTAINER No. 89

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – A conceptual system for containing and neutralizing hazardous materials by filtration. The system consists of a hermetically-sealed container vented to a filter medium which is in turn vented to atmosphere.

OPERATING PRINCIPLE – The hazardous material is sealed in the container and flows through an internal vent into a filter medium. When the pressure inside the container exceeds atmospheric pressure, a vent from the filter medium to atmosphere opens, releasing the filtered material.

PHYSICAL SPECIFICATIONS – Rigid, double-walled, hermetically-sealed container.

Filter medium between inner and outer walls.

Warning device to indicate if hazardous material concentration in the filter medium is too high.

Fiberglass storage container with metal filter compartments.

OPERATING SPECIFICATIONS – Sustained ambient temperatures would have to be higher than the freezing point of the contained contaminant. Also, compatible filter media would have to be used. No operating criteria were obtained.

STATUS OF DEVELOPMENT AND USAGE – Patented concept that has undergone limited testing.

PERFORMANCE – Testing showed the container was capable of removing methylbromide from a hazardous material by filtration through a charcoal filter.

AVAILABILITY AND COMMERCIAL INFORMATION –

A & J Manufacturing Co.
Airport Station
Los Angeles, CA 90009
U.S.A.
Telephone (213) 678-3053

OTHER DATA – This is a patented invention of Arch L. Young, assigned to the A & J Manufacturing Co.

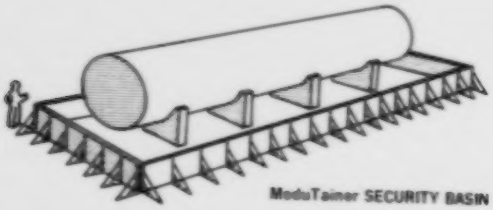
Reference: U.S. Patent 4 014 670

PRODUCT MODULAR HOLDING TANKS No. 90

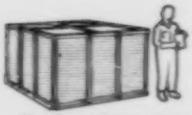
APPLICABILITY

Gas	Liquid Sol	Liquid Fl	Liquid Sk	Solid Sol	Solid Fl	Solid Sk
	*	*	*			

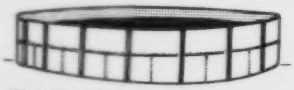
DESCRIPTION – A variety of lined tanks comprised of portable modular components that range from bolt-together steel units either circular or rectangular in configuration to free-standing smaller package systems that can be quickly assembled using panels and support frames.



ModuTainer SECURITY BASIN



ComPakt SMALL TANK



ModuStor BOLT-TOGETHER STEEL TANK

OPERATING PRINCIPLE – ComPakt and EconoStor models are small and medium size tanks, respectively, that are assembled from modular steel panels and steel support posts using simple hand tools. The tanks are lined with a flexible membrane and can be covered, insulated and fitted with piping to facilitate temporary storage of a variety of chemicals. All components can be hand carried.

ModuStor units are similar in design but are circular in configuration and available in larger capacities. They must be erected on a level, prepared site and can be anchored to concrete footings.

The ModuTank systems are rectangular in shape and incorporate the same design features as the other models, namely individual panels, support posts, liners, covers and optional piping arrangements. An exterior system of angled supports maintains the sidewalls in a vertical position.

Modutainer is an identical concept to ModuTank that can be erected around existing storage tanks as a means of potential spill containment.

PHYSICAL SPECIFICATIONS –

ComPakt Tanks

Model	Size m (ft)	Capacity L (U.S. gal)	Shipping Weight kg (lb)	Shipping Volume m^3 (ft^3)
960-250	0.9 x 0.9 (3 x 3)	946 (250)	104 (229)	0.25 (9)
960-500	1.2 x 1.2 (4 x 4)	1817 (480)	159 (350)	0.31 (11)
960-750	1.5 x 1.5 (5 x 5)	2839 (750)	177 (390)	0.37 (13)
960-100	1.8 x 1.8 (6 x 6)	3785 (1000)	204 (450)	0.42 (15)
960-125	2.0 x 2.0 (6.5 x 6.5)	4732 (1250)	236 (520)	0.48 (17)
960-150	2.1 x 2.1 (7 x 7)	5678 (1500)	268 (590)	0.54 (19)

All tanks are 1.2 m (4 ft) deep

Top covers in sheet steel, plywood, etc. can be added.

EconoStor Tanks

Ten models are available. Specifications are presented for the smallest, medium size and largest units.

Model	Size m (ft)	Capacity L (U.S. gal)	Shipping Weight kg (lb)	Shipping Volume m^3 (ft^3)
960-202	2.1 x 2.1 (7 x 7)	7571 (2000)	680 (1499)	1.42 (50)
960-304	3.2 x 4.3 (10.5 x 14)	22 712 (74 500)	1225 (2700)	2.41 (85)
960-606	6.4 x 6.4 (21 x 21)	68 137 (22 354 600)	1973 (4350)	3.88 (137)

All tanks are 1.9 m (6 ft) deep with capacity based on a 1.7 m (5.6 ft) liquid depth.

ModuStor Tanks

Eight models based on diameter are available; small, medium and large diameter units are reviewed.

Depth m (ft)	Diameter m (ft)	7.6 (25)		15.2 (50)		30.5 (100)	
2.4	Capacity L (U.S. gal)	108 262	(28 600)	433 050	(114 400)	1.7×10^6	(0.5 x 26 000)
	Weight kg (lb)	2 313	(5 099)	4 400	(9 700)	10 432	(23 000)
3.0	Capacity L (U.S. gal)	146 873	(38 800)	541 312	(14 300)	2.2×10^6	(0.58 x 264 000)
	Weight kg (lb)	2 495	(5 500)	4 990	(11 001)	12 701	(28 000)
3.7	Capacity L (U.S. gal)	162 772	(43 000)	649 196	(171 500)	2.6×10^6	(0.7 x 264 000)
	Weight kg (lb)	3 357	(7 401)	7 212	(15 899)	18 325	(40 400)
4.6	Capacity L (U.S. gal)	203 541	(53 770)	811 968	(214 500)	3.2×10^6	(0.85 x 264 000)
	Weight kg (lb)	4 445	(9 800)	9 752	(21 500)	22 816	(50 300)

ModuTanks/ModuTainers

Three typical sizes of tanks are:

Dimensions m (ft)		Capacity L (U.S. gal)		Approx. Shipping Weight kg (lb)	
4.7 x 4.7	(15 x 15)	30 283	(8000)	953	(2101)
16.2 x 18.4	(53 x 60)	378 540	(100 000)	2 994	(6600.5)
45.9 x 59.4	(150.5 x 195)	3 785 400	(1 000 000)	13 290	(29 300)

All tanks 1.45 m (4.75 ft) deep; capacity is estimated with 7.6 cm (3 in.) of freeboard.

All categories of tanks made by ModuTank Inc. are comprised of prefabricated modular steel components which include 16 gauge galvanized wall panels and steel angle iron, stainless steel fasteners, and stainless cable systems (ModuTank and ModuTainer only).

Liners for tanks are available in 20 and 30 mil PVC, 40-60-80 and 100 mil (high density polyethylene), 30 mil reinforced Hypalon, 30 mil reinforced Chemflex, 30 mil reinforced XR-5 and 30 mil oil-resistant PVC.

OPERATING SPECIFICATIONS – The manufacturer should be consulted for the chemical compatibility of the various liner options.

ComPakt tanks can be transported by stationwagon-sized vehicles, they feature components that can be hand carried; and they are free-standing units once assembled using hand tools.

EconoStor tanks are also designed for quick assembly using hand tools; they feature components that can be hand carried; and then provide free-standing storage on level or slightly sloping or undulating surfaces because of built-in adjuster panels.

ModuStor cylindrical tanks require firm, level surfaces for erection. Generally, eight to ten days are required by five workmen and a supervisor for assembly using ordinary tools. ModuTanks, ModuTainers feature parts that can be hand-carried by one or two workers. A typical tank 30 x 15 m (98 x 49 ft) can be installed by six unskilled labourers and a supervisor in about eight hours using simple hand tools.

STATUS OF DEVELOPMENT AND USAGE – Commercial products specifically conceived as highly portable, modular systems in wide use for the temporary storage of a range of liquids including many hazardous materials.

PERFORMANCE – Limited evaluation data were obtained. O.H. Materials, Inc., a cleanup contractor, reports the use of a 378 540 L (100 000 U.S. gal) tank with no operational problems. (The company primarily utilizes storage systems of their own design).

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

ModuTank Inc.
29-24 40th Ave.
Long Island City, NY 11101
U.S.A.
Telephone (212) 392-1112

OTHER DATA – None obtained.

Reference: Personal Communication, O.H. Materials, Inc. (June 28, 1984).

The various sizes of tanks, configurations, liners and overall modular approach appear to be well suited for hazardous material spill cleanup.

CONCEPT REPOSITORY FOR FISSILE MATERIALS No. 91

	Gas	Liquid			Solid		
APPLICABILITY		Sol	Fl	Sk	Sol	Fl	Sk
		*	*	*	*	*	*

DESCRIPTION – Concept only. A repository for holding and storing fissile or other hazardous materials by enclosing one or more inner containers in a larger, corrosion-resistant outer shell with a layer of foamed polyurethane in between.

OPERATING PRINCIPLE – The inner containers are spaced apart in the outer tube. One of the end caps is placed on the tube and is erected to stand upright on that end. The inner containers are supported in their desired positions and liquid polyurethane is poured into the tube through the open end. The upper end cap is put in place and the polyurethane is foamed to fill the gap between the containers and the tube walls. The foam is then allowed to set.

PHYSICAL SPECIFICATIONS –

Outer tube is made of bitumized fibre material.
End caps are of exterior grade plywood treated with creosote wood preservative.
Inner containers are standard 208 L steel drums.
Polyurethane is foamed with a trichlorofluoromethane foaming agent.

OPERATING SPECIFICATIONS – Polyurethane foam protects inner drums from destruction caused by electrolysis, cathodic action, and bacterial enzymes; offers thermal protection against freeze-thaw cycles; and mechanically reinforces inner containers and outer tube to give maximum strength.

Polyurethane is formed by reacting a polyisocyanate with a polyol; the heat of reaction is sufficient to activate foaming agent and cause foaming, except adjacent to containers and tube where temperature is moderated. This gives a foamed polyurethane liner with crystalline surfaces adjacent to inner containers and outer tube.

Inner containers equipped with water-soluble packages of fluorescein dye to indicate any accidental leakage of hazardous material.

Repositories designed for economical and safe storage and disposal of radioactive and other hazardous waste materials over long periods of time.

STATUS AND DEVELOPMENT AND USAGE – Patented concept with usage not documented.

PERFORMANCE – No evaluation data obtained.

AVAILABILITY AND COMMERCIAL INFORMATION –

Commercial production pending.

U.S. Ecology
P.O. Box 7246
Louisville, KY 40207
U.S.A.
Contact: Mr. Gary Young

OTHER DATA – This respository is the patented invention of Kenneth A. Gablin, assigned to the Nuclear Engineering Co. Inc., Louisville, Kentucky.

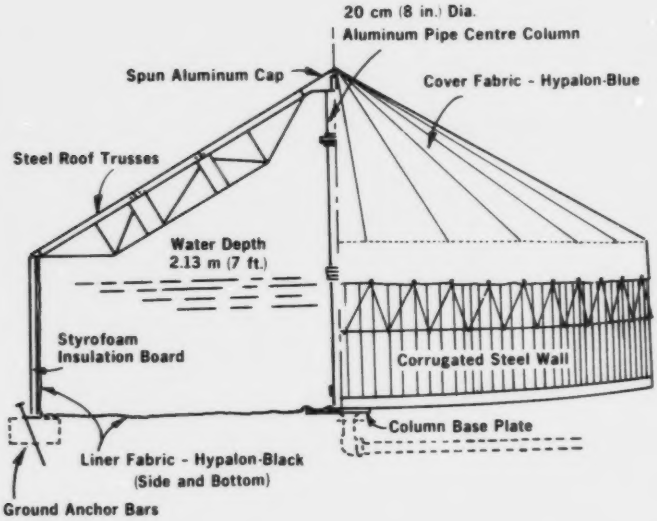
Reference: U.S. Patent 3 935 467.

PRODUCT UNITIZED PORTABLE RESERVOIR SYSTEM **No. 92**

APPLICABILITY

Gas	Liquid Sol	Liquid Fl	Liquid Sk	Solid Sol	Solid Fl	Solid Sk
	*	*	*			

DESCRIPTION – An all-weather reservoir designed for the temporary or permanent storage of a range of products, including hot and caustic liquids and petroleum-based products, unitized for portability and quick erection.



OPERATING PRINCIPLE – The circular reservoir is constructed on a level site by fitting the wall sections into a "wall ring" and securing them by a patented hinge and hook system. Material is pumped in and out of the reservoir through subterranian service pipes connected to a hollow centre column supporting the roof.

PHYSICAL SPECIFICATIONS – Seven models are available

	Capacity		Diameter Inside		Space Req. Dia.		Height to The Top		Weight	
No.	m^3	(Imp. gal)	m	(ft)	m	(ft)	m	(ft)	kg	(lb)
20	100.00	(22 025)	7.70	(25.26)	13.72	(45)	4.75	(15.57)	3538	(7800)
24	144.54	(31 769)	9.26	(30.38)	15.28	(50)	5.14	(16.82)		
30	226.32	(49 785)	11.60	(38.06)	17.62	(58)	5.81	(19.05)	6577	(14 500)
36	326.25	(71 768)	13.94	(45.72)	19.96	(65 1/2)	6.48	(21.25)		
45	510.24	(112 240)	17.43	(57.20)	23.45	(77)	7.48	(24.55)		
60	907.87	(199 710)	23.27	(76.34)	29.29	(96)	9.16	(30.06)		
72	1307.51	(287 620)	27.92	(91.61)	33.94	(111 1/2)	10.51	34.47		

Details on weights for other models available on request.

- Materials of construction include aluminum, stainless steel, or PVC (Hypalon liner). All steel components including nuts, bolts and washers are hot-dipped galvanized.
- Components packed on 1.2 m (4 ft) pallets, with no component longer than 2.4 m (8 ft) and no pallet load exceeding 680 kg (1500 lb).
- 1.2 x 2.4 m (4 x 8 ft) galvanized corrugated steel wall panels.
- 2.5 cm (1 in) styrofoam board is supplied.
- 3 sections 20.3 cm (8 in) aluminum centre column, with adjustable gap between two sections to provide overflow level control.
- Steel centre base plate with pre-attached service pipes.
- One piece polymer liner (Hypalon (Burke Rubber Company), 36 and 45 mil) suggested secured to top of steel shell by stainless steel "S" hooks.
- Two roof covers:

    1) Heavy nylon supplied with special "pulley-jig" for quick construction; secured walls by nylon rope through grommets spaced at 0.6 m (2 ft) intervals.

    2) Sectionalized galvanized metal.

- Sectionalized roof trusses made of hollow steel tubing, round rods, and flat bar.

OPERATING SPECIFICATIONS – Two trained personnel can prepare the site (level ground and dig pipe trench) and erect the 227 300 L (50 000 Imp. gal) reservoir in approximately 4 days.

STATUS OF DEVELOPMENT AND USAGE – Commercial product developed specifically for the storage of a variety of liquids including potable water, hot and caustic liquids, and a range of petroleum-based products.

PERFORMANCE – One of three 227 300 L (60 046 U.S. gal) reservoirs bought by the Government of Ontario was used as a temporary water reservoir in Woodville, Ontario during an overhaul of the municipal reservoir. A concrete pad was constructed since the reservoir was operated for approximately 6 months. A Hypalon liner was used.

Suggested applications include:
- waste containment
- potable water storage; and
- processing and product storage.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Columbia Reservoir Systems (1977) Ltd. (Restech)
Suite 23 - 566 Cardero Street
Vancouver, British Columbia
Canada
V6G 2W6
Telephone (604) 681-5623 or
263-4666

Canadian Distributor:

Task Force Enterprises
P.O. Box 311
Orleans, Ontario
Canada
K1C 1S7
Telephone (613) 824-7431
Contact: Mr. Clayton E. Beattie,
President

OTHER DATA – Information based on: personal communication with C.E. Beattie, November 3, 1983.

Columbia Reservoir Systems brochure. "All Weather-Durable-Reservoirs for Permanent or Temporary Storage. Unitized for Portability and Quick Erection." 1983.

3.3 Liners

PRODUCT POLYMERIC MEMBRANES - GENERAL LISTING **No. 93**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
*	*	*	*	*	*	*

Less applicability to containing vapours and gases is likely although the use of membranes has been proposed for this purpose.

DESCRIPTION – A variety of synthetic polymeric materials can be used for containing spills subject to material compatibility considerations. Although primarily designed for the lining of liquid impoundments or landfills, their use has also been suggested for bottom sealing of sunken substances or for containing, vapours of floating, volatile substances. Some of these materials have also been used for boom skirts, as flexible containers and as tank liners.

OPERATING PRINCIPLE – Synthetic membrane liners are most likely to be used in remote areas to contain a variety of spilled hazardous materials especially where substantial volumes must be temporarily held. Panels or sheets are usually transported to the spill site where they are seamed together using heat sealing, cementing or solvent welding techniques. In some cases, continuous sheeting or factory-seamed liners are used.

PHYSICAL SPECIFICATIONS –

Membranes are available in a wide range of plastics and elastomers including:

Polyethylene (low density and high density)
Polyvinyl chloride (PVC)
Butyl rubber
Ethylene propylene diene monomer (EDPM)
3110 (Du Pont trade name - elasticized polyolefin)
Chlorinated polyethylene (CPE)
Neoprene
Chlorosulphonated polyethylene (Hypalon)
Shelter-Rite XR5 (Seaman Corporation trade name)
Polypropylene

Examples of physical properties are as follows:

	Polyethylene							
	Low Density	High Density	PVC*	CPE	Poly-propylene	Butyl Rubber	Hypalon	EPDM
Specific Gravity	0.92 to 0.94	0.94 to 0.96	1.24 to 1.30	1.35 to 1.39	0.9 to 0.91	0.92 to 1.25	1.4 to 1.5	1.15 to 1.21
Tensile Strength (kPa)	8963 to 17238	16548 to 33096	17238 to 24133	≥12411	27580 to 220640	6895 to 27580	6855 to 13790	8964 to 10343
Elongation (%)	200 to 800	10 to 650	250 to 350	375 to 575	40 to 400	≥300	300 to 500	≥300

* plasticized

Other properties include material weight, breaking strength, abrasion resistance, adhesion of plies, adhesion of seams, water absorption and wicking.

Sheets available in standard sizes up to 12 m (39 ft) wide, 200 m (656 ft) long and 1 to 5 mm (0.04 to 0.019 in) thick depending on materials. Sheets can be provided with reinforcing fabrics for added strength.

OPERATING SPECIFICATIONS –

	Polyethylene							
	Low Density	High Density	PVC*	CPE	Poly-propylene	Butyl Rubber	Hypalon	EPDM
Operating Temp. (°C)	-57 to 82	- 57 to 116	-51 to 93	-40 to 93	-51 to 104	-46 to 163	-43 to 93	-59 to 149
Resistance to acids	P-G	G	G-E	G-E	G-E	G	G	G-E
Resistance to bases	G-E	G-E	G-E	G-E	G-E	G	G-E	G-E
Resistance to oxygenated solvents	P-G	P-G	G	P	P	G-E	G	G-E
Resistance to aromatic and halogenated solvents	F-G	F-G	G	P	G	P	F	P
Resistance to aliphatic (petroleum) solvents	F-G	F-G	G	G	G	P	G	P
Water vapour permeability perm-mils	3-14	1.8-2.2	3-18	0.04 - 0.048	0.25 - 1.0	0.15	2.0	2.0
Weatherability	P-w/o black	P-w/o black	P-F	E	P-w/o black	G	E	E
Time to crack (h)	900	300	no crack to 2500	no effect to 4000	100	no effect after 2500	no effect after 1000	no effect after 1000

* plasticized, P is poor, F is fair, G is good and E is excellent.

Specific information should be requested from manufacturers for compatibility of liners with specific hazardous materials as well as resistance to ozone, UV radiation, physical stressing and mold or fungus.

STATUS OF DEVELOPMENT AND USAGE – Commercially available products universally marketed.

Commonly used for lining chemical impoundements and landfills, and construction of boom skirts, flexible containers and tank liners.

Hypalon membrane marketed by Globe Linings Inc. with polyurethane floats for vapour suppression of spills on water. Also, similar system by Gulf Seal Corporation provides polyethylene foam underlay to float the sealing membrane.

PERFORMANCE – Comprehensive evaluations have been conducted on membrane liners for a wide variety of chemicals. The following references should be consulted:

(1) Haxo, H.E., Haxo, R.S. and White, R.M., Liner Materials Exposed to Hazardous and Toxic Sludges, First Interim Report, June 1977, Report EPA-600/2-77-081.

(2) Fung, R., Protective Barriers for Containment of Toxic Materials, Noyes Data Corporation, Park Ridge, NJ, U.S.A., 1980.

The information contained in these references also pertains to the physical and operating characteristics of synthetic membranes.

AVAILABILITY AND COMMERCIAL INFORMATION – Representative companies only are given. For additional firms consult industrial registers and telephone directories.

Carlisle Tire and Rubber Co.
Division of Carlisle Corporation
P.O. Box 99
Carlisle, PA 17013
U.S.A.
Telephone (717) 249-1000
(EPDM, butyl rubber and neoprene)

Lexcan Industrial Supply Limited
85 Vulcan Street
Rexdale, Ontario
Canada
L1A 1A1
Telephone (416) 249-8361
Telex 04-352815

E.I. Du Pont de Nemours & Company Inc.
Elastomers Division
3245 Sunnyside
Brookfield, IL 60513
U.S.A.
Telephone (312) 485-6881
Contact: Mr. G.E. Fisher
(Hypalon, 3110, neoprene)

ModuTank Inc.
29-24 40th Avenue
Long Island City, NY 11101
U.S.A.
Telephone (212) 392-1112

Shelter-Rite (Shelter-Rite XR5)
Division of Seaman Corporation
P.O. Box 331
102 North Washington Street
Millersburg, OH 44654
U.S.A.
Telephone (216) 674-2015
Contact: Mr. B. Venkataraman

Schlegel Lining Technology Inc. (HDPE)
P.O. Box 9115, Station "F"
Calgary, Alberta
Canada
T2J 5S7
Telephone (713) 273-3066
Contact: Mr. B.J. Thomson

B.F. Goodrich Canada Limited
521 King Street West
Kitchener, Ontario
Canada
N2G 1C5
Telephone (519) 742-3641
(EPDM, butyl rubber, PVC and
polyethylene)

Gundle Lining Systems
301-255 1st St. West
North Vancouver, B.C.
Canada
V7M 3G8
Telephone (604) 980-8337

Goodyear Tire and Rubber Company
1210 Massillon Road
Akron, OH 44306
U.S.A.
Telephone (216) 794-4002
Contact: Mr. D. Herehler

Pantasote Company of New York Inc.
98 Glenview Avenue
Toronto, Ontario
Canada
M4R 1P8
Telephone (416) 481-3504
(PVC and CPE)

Sarnafil Canada Limited (LDPE and HDPE)
75 Horner Avenue
Toronto, Ontario
Canada
M8Z 4X7
Telephone (416) 259-9203

Stevens Elastomeric and Plastic Products
Inc. (CPE)
Easthampton, MA 01027
U.S.A.
Telephone (413) 527-0700

OTHER DATA – Provincial, Territorial, State, Federal or local government requirements may exist insofar as liner use or performance is concerned. Appropriate regulatory authorities should be consulted prior to the installation of a facility to receive hazardous materials.

References: Ware, S.A. and Jackson, G.S., Liners for Sanitary Landfills and Chemical and Hazardous Waste Disposal Sites, Report EPA-600/9-78-005 (May, 1978).

Greer, J.S., Feasibility Study of Response Techniques for Discharges of Hazardous Chemicals that Float on Water, Report CG-D-56-77 (1977).

Fung, R., Protective Barriers for Containment of Toxic Materials, Noyes Data Corp., Park Ridge, NJ, U.S.A. (1980).

4 TRANSFER

4 TRANSFER

4.1 Transfer of Liquids

PRODUCT AMERICAN TEFLON AND POLYPROPYLENE PUMPS **No. 94**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – Air-operated, double-acting diaphragm pumps manufactured from chemical-resistant materials.

OPERATING PRINCIPLE – A double-acting diaphragm pump consists of two chambers divided by a flexible diaphragm. A drive shaft is connected to the centre of the diaphragm. Reciprocating movement of the shaft bends the diaphragm, simultaneously enlarging one chamber while decreasing the other. Fluid enters when the cavity is enlarged and discharged during contraction. Check valves control the direction of flow.

PHYSICAL SPECIFICATIONS –

	25.4 mm Pumps (1 in)	50.8 mm Pumps (2 in)
Dimensions (mm)	356 x 343 x 305 high	457 x 445 x 330 high
Suction and Discharge Connections	25.4 mm male N.P.T.	50.8 mm male N.P.T.
Air Inlet Connections	6.4 mm female pipe thread	12.7 mm female pipe thread
Weight (net)	Teflon: 31 kg Polypropylene: 15 kg	Teflon: 102 kg Polypropylene: 61 kg
Air Pressure	6.9 to 689.5 kPa	13.8 to 689.5 kPa

Materials of Construction:

	Teflon Pumps	Polypropylene Pumps
Wetted Parts	Teflon	Polypropylene
Valve Design	Teflon-ball	Teflon-ball
Diaphragm	Teflon	Teflon
O-Rings	Teflon	Teflon

All pumps are explosion-proof.

OPERATING SPECIFICATIONS –

	25.4 mm Pumps (1 in)	50.8 mm Pumps (2 in)
Capacity (L/s)	0.03 to 1.89	0.13 to 7.6
Solid Particle Sizes (mm)	up to 9.5	up to 15.9

Self-priming
Able to run dry without damaging pump.
Temperature-resistant up to approximately 104°C.
Seal-less and leak-proof.

STATUS OF DEVELOPMENT AND USAGE – Commercially available for use with many industrial chemicals (see Performance).

PERFORMANCE – The polypropylene pumps can transfer the following chemicals:

Acetic Acid
Acetic Anhydride
Ammonium Nitrate
Ammonium Phosphates
Benzene
Calcium Carbonate
Calcium Chloride
Calcium Oxide/Hydroxide
Carbon Dioxide
Ethylene Dichloride
Ethylene Glycol
Ferric Chloride
Formaldehyde
Hydrogen Chloride/Acid
Hydrogen Fluoride/Acid
Hydrogen Sulphide
Mercury
Methanol
Phenol
Phosphoric Acid
Potash (Potassium Chloride)
Sodium Chlorate
Sodium Chloride
Sodium Hydroxide
Sodium Hypochlorite
Titanium Dioxide
Urea
Xylenes
Zinc Sulphate
Acetaldehyde
Acetone
Adipic Acid
Aluminum Chloride
Aluminum Sulphate
Ammonium Chloride
Ammonium Sulphate
Barium Sulphate
Borax
Boric Acid
Butanols
Butylene
Calcium Hypochlorite
Copper Sulphate
Creosote
Dichlorobenzene
Ethanol
Hydrogen Peroxide
Isopropanol
Magnesium Hydroxide
Methyl Ethyl Ketone
Methyl Isobutyl Ketone
Methylamines
n-Butanol
n-Hexane
Potassium Carbonate
Potassium Sulphate
Sodium Carbonate
Sodium Cyanide
Sodium Dichromate
Sodium Nitrate
Sodium Silicates
Sodium Sulphate
Sodium Sulphite
Stearic Acid
Turpentine
Uranium Compounds
Zinc Chloride

The teflon pumps can accommodate the following chemicals in addition to the above:

Ethylene Oxide
Naphthalene
Nitric Acid
Propylene Oxide
Sulphuric Acid (and Oleum)
Toluene
Carbon Disulphide
Carbon Tetrachloride
Chloroform
Cyclohexane
Ethyl Chloride
Ethylene Bromide
Perchloroethylene
Tall Oil

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

American Pump Company, Inc.
P.O. Box 2680
Springfield, MA 01101
U.S.A.
Telephone (413) 781-3280

Distributor:

Hydro Dynamics Ltd.
482 McNicoll
Willowdale, Ontario
Canada
M2H 2E1
Telephone (416) 499-0360

Other distributors in Montreal (Québec), Edmonton and Calgary (Alberta).

OTHER DATA –

Cost (1981 Prices):

25.4 mm Pumps:	Polypropylene (No. 130)	$ 3800
(1 in)	Teflon (Brute)	$ 6400
50.8 mm Pumps:	Polypropylene (No. B230)	$ 7800
(2 in)	Teflon (B2)	$12 000

Reference: Manufacturers' Literature.

PRODUCT BELL & GOSSETT CENTRIFUGAL PUMPS **No. 95**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – A line of centrifugal pumps with components resistant to chemical corrosion.

OPERATING PRINCIPLE – A centrifugal pump consists of an impeller rotated inside a casing by a drive shaft extending outside the casing from the axis of the impeller. Rotation causes fluid to enter the centre (eye) of the impeller and flow outward along the impeller vanes. The tangential velocity head imparted to the fluid changes to a pressure head as the fluid flows along the inner casing (volute) and out the discharge port.

PHYSICAL SPECIFICATIONS –

Series 60

Impeller keyed to shaft.
Mechanical seal of carbon seal ring and ceramic seat.
Shaft sleeve in wetted area of mechanical seal.
Bearing bracket has oil-lubricated bronze journal bearings with a hardened alloy steel shaft.
Flexible coupling to dampen starting torque and torsional vibrations.
Iron with bronze fittings construction available as all iron or all bronze.

Series 80

Open drip-proof motor enclosures (total encapsulated and explosion-proof motors are optional).
Shaft sleeve protects wetted portion of shaft.
Impeller keyed to shaft and secured with locknut and washer.
Four seal options available.

Series 1510

Vertical split case design manufactured from iron with bronze fittings, or all iron or all bronze construction.
Shaft sleeve protects wetted portion of shaft.
Solid-type volute.
Enclosed impeller.
Four seal options available.

Series 1522

Coupled to motor by spring-type coupling.
Mechanical seal of carbon steel ring and ceramic seat.
Enclosed impeller keyed to shaft.
Vertical split case design manufactured from iron, bronze or stainless steel with bronze fittings.

Series 1531

Drip-proof motors (explosion-proof or encapsulated enclosures available).
Vertical split casing.
Four seal options available.
Impeller locked to shaft by key.

OPERATING SPECIFICATIONS –

Capacities (approximate)

	Maximum Head (m)	Maximum Pumpage (L/s)	Working Pressure (Optional) (kPa)
Series 60	17.4	8.8	1207
Series 80	119.7	164.0	1207 (1724)
Series 1510	128.0	170.3	1207
Series 1522	31.4	8.5	1207
Series 1531	121.9	164.0	1207 (1724)

STATUS OF DEVELOPMENT AND USAGE – Commonly used by the chemical processing industries.

PERFORMANCE – The following chemicals (or solutions of them) are claimed by the manufacturer to be compatible with the Bell & Gossett centrifugal pumps:

Acetaldehyde
Acetone
Acetonitrile
Acetylene
Acrolein
Acrylonitrile
Amyl Acetate
Aniline
Arsenic Trioxide
Barium Carbonate
Benzene
Ethylbenzene
2-Ethyl Hexanol
Ethylene
Ethylene Oxide
Fluorine
Formaldehyde
Furfural
Glycerine
N-Hexane
Isopropyl Acetate
Isopropyl Alcohol
Lead Acetate
Lead Nitrate
Butadiene
Butyl Alcohols
Butylenes
Butyraldehydes
Calcium Carbide
Calcium Oxide
Caprolactam
Carbon Disulphide
Carbon Monoxide
Cellulose Acetate
Chlorobenzene
Liquid Natural Gas and Petroleum Gas
Mercury
Methane
Methanol
Methyl Chloride
Methyl Ethyl Ether
Methyl Ethyl Ketone
Monomethylamine
Naphtha Solvent
Naphthalene
Pentachloroethylene
Phenol
Potassium Cyanide
Chloroform
Copper Sulphate
Cresol
Cumene
Cumene Hydroperoxide
Cyclohexane
1,2-Dichlorobenzene
Dimethylether
Dimethylamine
Ethylacrylate (Monomer)
Ethyl Acetate
Potassium Chloride (Potash)
Potassium Dichromate
Propane
Propylene Oxide
Sodium Chlorate
Sodium Hydrosulphite
Sodium Hydroxide
Styrene Monomer
Sulphur
Tetraethyl Lead
Toluene
Trichloroethylene
Xylenes

The following chemicals have been processed by this line of pumps in the past:

Acetone
Benzene
Butyl alcohols
Butylenes
Ethyl Alcohol
Ethylene
Glycerine
Isopropyl Alcohol
Propylene
Sodium Hydroxide
Trichloroethylene

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Bell & Gossett
Morton Grove, IL 60053
U.S.A.
Telephone (312) 966-3700
Contact: Mr. R.D. Von Gillern

Distributor:

ITT Industries of Canada Limited
55 Royal Road
Guelph, Ontario
Canada N1H 1T1
Telephone (519) 821-1900

OTHER DATA – No other information obtained.

Reference: Manufacturer's Literature.

PRODUCT CHEMTROL CENTRIFUGAL PUMPS **No. 96**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – A line of centrifugal pumps constructed of chemically-resistant materials.

OPERATING PRINCIPLE – Centrifugal pump consists of an impeller rotated inside a casing by a drive shaft extending outside the casing from the axis of the impeller; rotation causes fluid to enter the centre (eye) of the impeller and flow outward along the impeller vanes; the tangential velocity head imparted to the fluid changes to a pressure head as the fluid flows along the inner casing (volute) and out the discharge port.

PHYSICAL SPECIFICATIONS –

Model	Description	Materials of Construction	Connections		
			Maximum Suction (mm)	Maximum Discharge (mm)	Maximum Power (hp)
CP- 3000	Close Coupled	PVC or polypropylene	76	51	7-1/2
CP- 4000	Self-Priming	fiberglass reinforced epoxy	38	38	Not specified
CP- 5000	Motor Mounted	polypropylene	32	25	3
CP- 6000	Pedestal Mounted	PVC or polypropylene	76	51	10
CP- 7000	Vertical Sump Pump	CPVC	38	32	3
CP- 9000	Pedestal Mounted	polypropylene	32	25	2
CP-10000	Pedestal Mounted	reinforced epoxy resin	100	100	Not specified

PVC = Polyvinyl Chloride CPVC = Chlorinated Polyvinyl Chloride

Model	Maximum Head (m)	Maximum Flow (L/S)	Maximum Pressure (kPa)	Maximum Temperature (°C)
CP- 3000	39.6	12.6	862	—
CP- 4000	22.9	6.3	—	104.4
CP- 5000	21.3	5.7	517	82.2
CP- 6000	39.6	12.6	862	—
CP- 7000	22.9	5.7	—	82.2
CP- 9000	21.3	5.7	571	82.2
CP-10000	91.4	31.6	—	121.1

STATUS OF DEVELOPMENT AND USAGE – Commonly used by the chemical processing industries.

PERFORMANCE – The manufacturer claims the following chemicals are compatible with Chemtrol centrifugal pumps if constructed of appropriate materials:

Acetic Acid
Acetone
Aluminum Chloride
Ammonium Chloride
Calcium Hypochlorite
Carbon Tetrachloride
Chlorobenzene
Chromic Acid
Copper Chloride
Copper Sulphate
Ferric Chloride
Formaldehyde
Glycerine
Hydrochloric Acid
Hydrofluoric Acid
Hydrofluosilicic Acid
Hydrogen Peroxide
Methyl Ethyl Ketone
Phenol
Phosphoric Acid
Potassium Dichromate
Potassium Hydroxide
Sodium Chlorate
Sodium Hydroxide
Sodium Hypochlorite
Sulphuric Acid
Toluene
Zinc Chloride

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:	Distributor:
Thompson-Chemtrol 921 Greengarden Rd. Erie, PA 16501-1591 U.S.A. Telephone (814) 452-3185	John Vissers Sales Corporation 8481 Keele St., Unit 18 Concord, Ontario Canada L4K 1Z7 Telephone (416) 738-1555

OTHER DATA – None obtained.

Reference: Manufacturer's Literature.

PRODUCT CORCORAN CENTRIFUGAL PUMPS **No. 97**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – Horizontal and vertical centrifugal pumps constructed of chemical-resistant materials.

OPERATING PRINCIPLE – A centrifugal pump consists of an impeller rotated inside a casing by a drive shaft extending outside the casing from the axis of the impeller. Rotation causes fluid to enter the centre (eye) of the impeller and flow outward along the impeller vanes. The tangential velocity head imparted to the fluid changes to a pressure head as the fluid flows along the inner casing (volute) and out the discharge port.

PHYSICAL SPECIFICATIONS –

Horizontal Pumps (Close-coupled)

Model	Motors (hp)	Ports (mm)	Seals
1000-E	1/3 and 1/2	19 x 13	21 Buna-N, 21 Viton-A, or 9 Viton-A
2000-E	1/3 to 1/2	25 x 32, 32 x 38	21 Buna-N, 21 Viton, 9 Viton, or Type 9 Teflon
3000-D 4000-D and 5000-D	1/3 to 30	32 to 102	Neoprene, Buna-N, Viton-A, or Teflon
H	1/3 to 100	13 to 127	Teflon, Viton-A, or Buna-N

Vertical Pumps:

Model	Motors (hp)	Ports (mm)	Gaskets
VE, VEC	1/2 to 100	25 to 152	Buna-N or Teflon
DVEC, VC: Double Impeller (also available as a close-coupled, vertical, cantilever pump in Model)	1/2 to 100	25 to 152	Buna-N or Teflon
VECC Vertical, Cantilever, Shaft Pumps with Chair Mounts	1/2 to 100	25 to 152	Buna-N or Teflon

All pumps available in the following materials:

18-8 Stainless Steel
Type 316 Stainless
Carpenter 20 CB 3
Hastelloy B and C
Titanium
Zirconium
Tantalum
Monel
Nickel

OPERATING SPECIFICATIONS –

Horizontal Pumps	Capacities
Model 1000-E	0.3 L/s @ 6.1 m head (0.08 U.S. gal @ 20 ft)
Model 2000-E	6.3 L/S @ 8.5 m head (1.7 U.S. gal @ 28 ft)
Model 3000-D, 4000-D, 5000-D	0.6 to 22.1 L/s @ up to 121.9 m head (0.15 to 6 U.S. gal @ up to 400 ft)
Model H	0.6 to 63.1 L/s @ up to 164.6 m head (0.15 to 16.6 U.S. gal @ up to 540 ft)
Vertical Pumps	0.6 to 56.8 L/s @ 4.6 to 73.1 m head (0.15 to 15 U.S. gal @ 15 to 240 ft)

STATUS OF DEVELOPMENT AND USAGE – Commonly used in the chemical processing industries.

PERFORMANCE – With appropriate selection of materials of construction, the manufacturer claims the following chemicals can be transferred by Corcoran centrifugal pumps:

Cleaners
Caustic Materials
Salt Solutions
Chlorinated Solvents
Photographic Chemicals
Deionized Water
Fatty Acids
Phosphoric Acid
Citric Acid
Lactic Acid
Sulphuric Acid
Chromic Acid
Plating Solutions
Hydrochloric Acid
Ferric Chloride
Nitric Acid
Chromic Acid
Chlorine Water

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

R.S. Corcoran Company
P.O. Box 246
500 Old Hickory Road
New Lenox, IL 60451
U.S.A.
Telephone (815) 485-2156

Distributor:

John Vissers Sales Corporation
8481 Keele St., Unit 18
Concord, Ontario
Canada
L4K 1Z7
Telephone (416) 738-1555

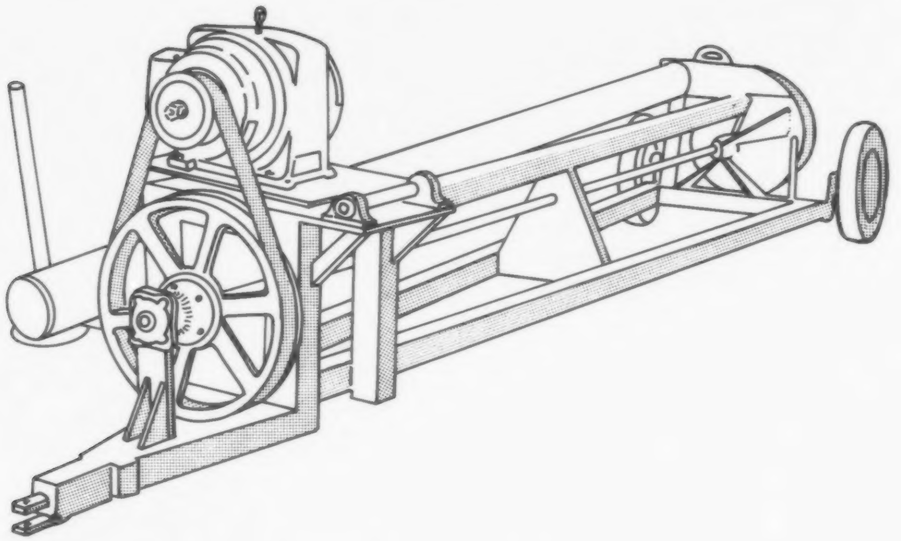
OTHER DATA – None obtained.

PRODUCT CRISAFULLI PUMPS **No. 98**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – Centrifugal, hydraulic, submersible, trailer-mounted and portable submersible pumps.



OPERATING PRINCIPLE – Trailer-mounted pumps are backed into reservoirs or canals and the pump driven by an external motor (e.g., tractor) or trailer-mounted motor. Hydraulic submersible pumps are driven by remote hydraulic power units (e.g., tractor power take-off).

PHYSICAL SPECIFICATIONS –

Portables

A two-wheeled trolley supporting a submersible pump at its base and an electric or gas-powered motor at the top.
Two models: 51 and 76 mm (2 and 3 in).

Submersible Hydraulic Series

Hydraulically-driven pumps. Typical power sources: back-hoes, loader tractors, tank trucks.

No shaft seals or housing seals reduces vulnerability to silt, sand, mud, sludge or abrasives.

All steel construction; standard sealed bearings.

Models available: 51, 62, 76, 102 and 152 mm (2, 2.5, 3, 4 and 6 in), single or double intake.

203, 254, 305 and 406 mm (8, 10, 12 and 16 in), double intake only.

Special epoxy-coated models available for high acid applications.

Portable Trailer Series

Two-wheeled trailer supporting a submersible pump above axles at one end.

Three designs available: Long Hitch 7.0 m (23 ft) trailer
Short Hitch 4.7 m (15 ft) trailer
Steep Angle 6.8 m (22 ft) trailer for pumps greater than 203 mm (8 in)

Pump sizes available: 102 to 610 mm (4 to 24 in).
Optional epoxy coating available for high acid applications.
Extension trailers available for additional reach.
All steel construction; standard sealed bearings.
No shaft seals or housing seals reduce pump vulnerability to silt, sand, mud, sludge or abrasives.

Slurry Pumps

Same as portable trailer models, but equipped with a "Slurry Gate" to facilitate agitation and mixing of viscous material.

Pump sizes available: 102 to 406 mm (4 to 16 in).

9.5 mm (3/8 in) steel plate construction.

OPERATING SPECIFICATIONS — A Crisafulli pump requires no priming, suction pipes screens, or check valves; and is self-draining.

Portables

51 mm - up to 9.5 L/s water.
76 mm - up to 37.9 L/s water.

Submersible Hydraulic Series

Total Head Developed: 0 to 15.2 m (0 to 50 ft).
Average Pump Flows: 9.5 to 252 L/s (150 to 4 000 U.S. gpm).

Portable Trailer Series

powered by gas, diesel or electric motors mounted on trailer, or by auxiliary motors (eg. tractor).
Capacities: 63 to 1514 L/s (1000 to 24 000 U.S. gpm).

Slurry Pumps

Pumping Rate @ 3 m T.D.H.: 69 to 240 L/s (1100 to 3800 U.S. gpm).
Horsepower (corresponding to above pumping rates): 20 to 135.

STATUS OF DEVELOPMENT AND USAGE — Crisafulli pumps are used for irrigation, flood control, fisheries, and industrial, municipal, and construction applications. Their use in response to hazardous material spills has not been documented to date.

PERFORMANCE — Crisafulli claims their pumps can transfer the following materials:

Acetaldehyde
Acetic Acid (5%)
Acetone
Ammonium Chloride
Ammonium Hydroxide
Ammonium Nitrate
Ammonium Phosphate
Carbonic Acid (Phenol)
Carbon Bisulphide
Carbon Dioxide
Carbon Tetrachloride
Carbonic Acid
Chlorinated Solvents
Ammonium Sulphate with H_2SO_4
Ammonium Sulphate
Benzene
Benzoic Acid
Bleach Solutions
Boric Acid
Calcium Chloride
Sodium Chloride
Sodium Cyanide
Sodium Hydroxide
Sodium Hydrosulphite
Sodium Hypochlorite
Sodium Nitrate

Chlorine
Copper Sulphate (Blue Vitriol)
Ethanol
Ethylene Chloride (cold)
Hydrochloric Acid
Hydrofluoric Acid
Hydrogen Peroxide
Latex
Mercury
Methyl Alcohol
Methylene Chloride
Perchloroethylene
Potassium Sulphate
Sodium Carbonate
Sodium Phosphate (mono)
Sodium Phosphate (di)
Sodium Phosphate (tri)
Sodium Phosphate (meta)
Sodium Silicate (water glass)
Sodium Sulphate
Sodium Sulphite
Sulphur (in water)
Sulphur (molten)
Sulphuric Acid (77%)
Tetraethyl Lead
Toluene (Toluol)
Trichloroethylene

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Crisafulli Pump Company, Inc.
P.O. Box 1051
Crisafulli Drive
Glendive, MO 59330
U.S.A.
Telephone (406) 365-3393
Contact: Ms. M. Shipley, Sales Division

Distributor:

Dow Equipment
P.O. Box 1777
Brantford, Ontario
Canada
N3T 5T9
Telephone (519) 752-3971

OTHER DATA – Crisafulli also markets vertical tank pumps, floating pumps and sludge handling systems. The company has developed pollution (including spill) control hardware in the past.

References: Manufacturer's Literature; personal communication, Ms. M. Shipley, Crisafulli Pump Company (March 16, 1981).

PRODUCT FLYGT SUBMERSIBLE PUMPS **No. 99**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – Submersible, abrasive-resistant, centrifugal pumps suitable for pumping certain hazardous chemicals.

OPERATING PRINCIPLE – These submersible pumps operate on the centrifugal principle (see Entry No. 96).

PHYSICAL SPECIFICATIONS –

Materials of Construction

All wetted metal parts are of stainless steel.
All impellers (two vane) are of stainless steel.
Standard rotating rings are of ceramic, the upper stationary seal is of carbon and the lower stationary seal is of solid sintered carbide.

Motor:

	Single Phase	Three Phase
Motor rating	2.5 hp	3.7 hp
Voltage	230 V	230/460/575 V
Current	60 cycle	60 cycle
Amperage (max.)	10.5	10/5/4
Input (max.)	390 W	300/300/300 W
rpm	3600	3600

Power:

Voltage	Starting Amps	Starting kW
230 V/1 phase	40	9.2
230 V/3 phase	56	22
460 V/3 phase	28	22
575 V/3 phase	22	22

Weight:

Series 2060: 29.5 kg (65 lb)
Series 3060: 43.0 kg (95 lb)

Discharge Flange:

Series 2060: 76 mm (3 in)

Series 3060: 64 mm (2.5 in) vertical (can be modified to 76 mm (3 in))

Built-in thermal overload protection (as required).

Should overheating occur, a contactor unit in the starting equipment cuts the control circuit by means of thermo-contacts built into the stator end winding. The pump cannot be restored until the temperature has returned to within operating limits.

Standard equipment for both series (2060, 3060) include: power cable, control box and discharge connection.

OPERATING SPECIFICATIONS – Maximum temperature of the pumped liquid for both series (2060, 3060) is 40°C (104°F) although with external cooling, the 3060 series can handle higher temperatures.

Series 2060:

can operate partially or fully submerged;
can handle liquids containing solids up to 6.4 mm (0.25 in) in diameter; and
can pump up to 20 L/s and heads up to 24 m (80 ft).

Series 3060:

can pump up to 18.9 L/s and heads up to 25.9 m (85 ft).

STATUS OF DEVELOPMENT AND USAGE – Submersible pumps are commercially available for use in the chemical processing industries, agriculture, and sewage treatment.

PERFORMANCE – The manufacturer claims the Flygt submersible pumps are compatible with the following chemicals:

Series 2060:

Material	Temperature Limit (°C)	Concentration (%)
Ammonium Hydroxide	20 (68°F)	All
Calcium Hydroxide	20 (68°F)	All
Potassium Carbonate	20 (68°F)	50
Sodium Carbonate	20 (68°F)	30
Boric Acid	40 (104°F)	All
Sulphuric Acid	20 (68°F)	10

Has limited resistance to the following material due to elastomers in construction.

Material	Temperature Limit (°C)	Concentration (%)
Caustic Soda	20	78
Phosphoric Acid	50*	50
Stearic Acid	40	All
Acetic Acid	40	50

* External cooling required over 40°C.

Series 3060:

Material	Temperature Limit (°C)	Concentration (%)
Ammonium Hydroxide	20	All
Potassium Hydroxide	20	15
Carbolic Acid	All	All
Calcium Hydroxide	20	All
Potassium Carbonate	20	50
Caustic Soda	20	78
Sodium Carbonate	20	30
Boric Acid	40	All
Phosphoric Acid	50*	20
Stearic Acid	40	All
Sulphuric Acid	40	10

Has limited resistance to acetic acid (15%) at 40°C due to elastomers in construction. * External cooling required over 40°C.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Flygt Canada
300 Labrosse Avenue
Pointe Claire, Quebec
Canada
H9R 4V5
Telephone (514) 695-0100

Other offices in Port Coquitlam, B.C., Calgary, Edmonton, Winnipeg, Rexdale, Hamilton, Sudbury, Nepean, Quebec City, Sept Iles, Moncton, St. John's.

OTHER DATA – Many other submersible pumps, supplied by Flygt, are available for other applications. These pumps are claimed to have good tolerance for solids.

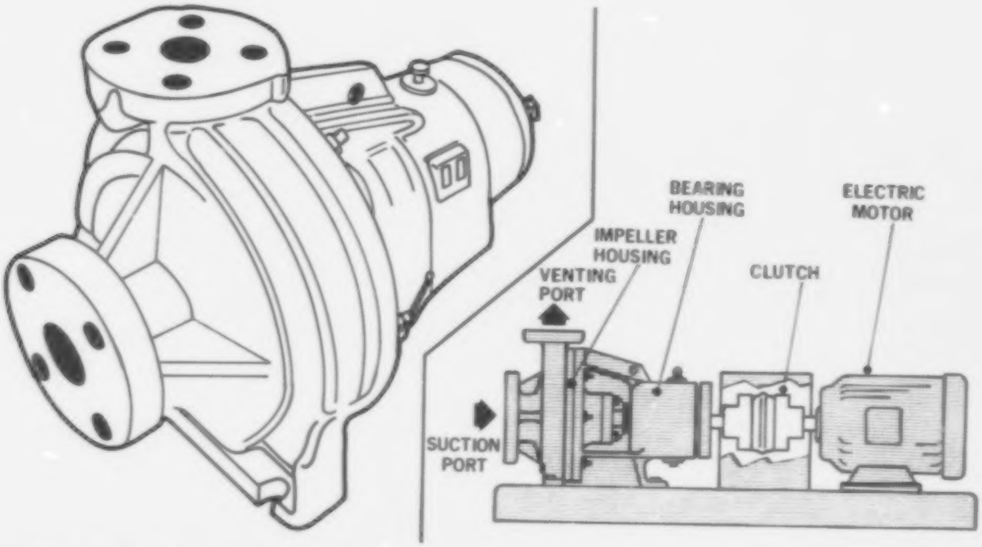
References: Manufacturer's Literature.

PRODUCT FYBROC FIBERGLASS PUMPS **No. 100**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – Centrifugal pumps manufactured from fiberglass for handling corrosive materials in the chemical processing industries.



OPERATING PRINCIPLE – See Entry No. 96.

PHYSICAL SPECIFICATIONS –

Available in the following models:

Series 1500 Horizontal Pump
Series 1000 and 2000 Horizontal Pumps
Series 3000 Recessed Impeller Horizontal Pump
Series 5000 Vertical Sump Pump
Series 6000 Recessed Impeller Vertical Pumps
Series 7000 Vertical Cantilever Pumps

Series	Available Suction Sizes mm (in)	Available Discharge Sizes mm (in)
1500	40 to 150 (1.5 to 6)	25 to 100 (1 to 4)
1000	51 to 102 (2 to 4)	25 to 76 (1 to 3)
2000	76 to 254 (3 to 10)	38 to 203 (1.5 to 8)
3000	51 to 203 (2 to 8)	25 to 152 (1 to 6)
5000	–	51 to 203 (2 to 8)
6000	–	51 to 152 (2 to 6)
7000	–	–

Materials of Wetted Parts

Series	1000	Glass-reinforced vinyl ester (or epoxy)
Series	2000, 3000	Glass-reinforced vinyl ester (or epoxy) Solid metal shaft in some models
Series	5000, 6000	Glass-reinforced vinyl ester (or epoxy) Teflon sleeve bearings
Series	7000	Glass-reinforced vinyl ester (or epoxy) Shaft, hardware, impeller key chosen to suit pumped material (i.e., 316SS, Carpenter 20, Titanium or Hastelloy Bk)

Other material formulations are available for elevated temperature services and abrasives.

General Physical Properties:

Tensile Strength 1034 to 3347 bar (15 000 to 50 000 psi)
Flexural Strength 2068 bar (30 000 psi)
Weight: 25 to 50% less than metal.
Non-magnetic, non-sparking, non-scoring.
Physical properties not affected by temperatures up to 99°C (210°F) with most liquids.

OPERATING SPECIFICATIONS –

Capacities (depending on size, speed, and TDH):

Series	up to L/s (U.S. gpm)
1000	35 (550)
2000	252 (4000)
3000	158 (2500)
5000	252 (4000)
6000	158 (2500)
7000	158 (2500)

STATUS OF DEVELOPMENT AND USAGE – Fybroc fiberglass process pumps have transferred most corrosive acids, caustics, liquid chemical wastes and slurries of mildly or non-abrasive solids in the chemical processing, pulp and paper, refinery, utility, and waste treatment industries.

PERFORMANCE – Fybroc pumps are claimed to be compatible with the following chemicals and their solutions:

Acetic Acid
Adipic Acid
Aluminum Chloride
Aluminum Hydroxide
Aluminum Sulphate
Ammonia (wet)
Ammonium Chloride
Ammonium Nitrate
Ammonium Phosphates
Ammonium Sulphate
Barium Sulphate
Benzene
Benzoic Acid
Potassium Carbonate
Potassium Sulphate
Propylene Glycols
Sodium Carbonate
Sodium Chlorate
Sodium Chloride
Sodium Cyanide
Sodium Dichromate
Borax
Boric Acid
Calcium Carbonate
Calcium Chloride
Calcium Hypochlorite
Calcium Oxide/Hydroxide
Carbon Tetrachloride
Chloroform
Copper Sulphate
Dichlorobenzene
Ethanol
Ethyl Chloride
Ethylene Glycol
Sodium Hydroxide
Sodium Hypochlorite
Sodium Nitrate
Sodium Phosphates
Sodium Silicates
Sodium Sulphate
Sodium Sulphite
Stearic Acid
Ferric Chloride
Formaldehyde
Hydrogen Chloride/Acid
Hydrogen Peroxide
Hydrogen Sulphide
Isopropanol
Magnesium Hydroxide
Methanol
Methyl Isobutyl Ketone
Naphthalene
Nitric Acid
Phosphoric Acid
Potash (Potassium Chloride)
Sulphuric Acid (and Oleum)
Toluene
Turpentine
Urea
Vinyl Acetate
Xylenes
Zinc Chloride
Zinc Sulphate

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Met-Pro Corporation,
Fybroc Division
235 Township Line Road
Hatfield, PA 19440
U.S.A.
Telephone (215) 723-8155
Telex: 846-361

Distributor:

Dynesco Equipment Sales Ltd.
923 Oxford St.
Toronto, Ontario
Canada
M8Z 5T3
Telephone (416) 252-5601

7575 Trans Canada Hwy
Montreal, Quebec
Canada
H4T 1V6
Telephone (514) 337-1505

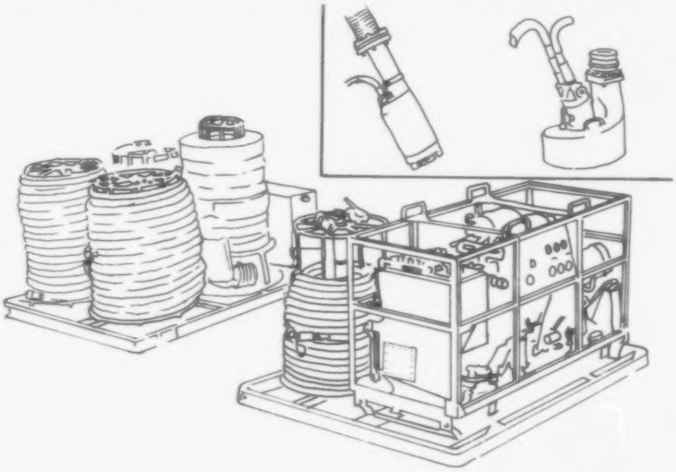
OTHER DATA – None obtained.

Reference: Manufacturer's Literature.

PRODUCT FRAMO SUBMERSIBLE PUMPS **No. 101**

APPLICABILITY	Gas	Liquid			Solid		
		Sol	Fl	Sk	Sol	Fl	Sk
		*	*	*			

DESCRIPTION – Portable hydraulically-driven, submersible pumps with self-contained hydraulic powerpacks for emergency off-loading of chemicals and light viscosity oils.



OPERATING PRINCIPLE – Centrifugal pumps powered by remote electro-hydraulic or diesel-hydraulic powerpacks. See Entry No. 96.

PHYSICAL SPECIFICATIONS –

	TK-4	TK-5
Weight, excl. hoses (kg)	60	70
Weight, inc. hydr. hoses (kg)	N/A	130
Height (mm)	N/A	653
Materials exposed to cargo	AISI 316 stainless steel and Teflon	
Max. Pump Diameter (mm)	300	300
Hydraulic Motor Type	Vane	Axial Piston

TK-5 pump supplied with 18 m (60 ft) of concentrically fitted pressure and return neoprene rubber hydraulic hoses, with control valve and snap-on couplings.

Powerpacks are mounted on compact skids with aluminum frames for transport by truck or helicopter.

Diesel-hydraulic Power Pack:

Weight includes oil and fuel to start: 1100 kg (2400 lb)
Length x width x height: 2100 x 800 x 1200 mm (82.5 x 31.5 x 47 in)
Capacity of Diesel Fuel Start Tank: 30 L (8 U.S. gal)

Electro-hydraulic Power Pack:

Consult manufacturer.

OPERATING SPECIFICATIONS –

	TK-4	TK-5
Design Capacity (m^3/h at 70 mwc head)	70	190
Maximum Capacity (m^3/h at 20 mwc head)	100	250
Hydraulic Working Pressure (bar)	150	320
Hydraulic Oil Flow (L/min)	145	130
Required Powerpack Output (hp)	60	100

STATUS OF DEVELOPMENT AND USAGE – Framo pumps were designed primarily for off-loading oil from disabled ocean tankers in emergency situations. Their application to smaller volume spills on land or in inland waters is feasible, but should be discussed with the manufacturer.

PERFORMANCE – Framo pumps transferred 34 000 tons of heavy Iranian crude oil from the 35 000 ton cargo of the grounded "Christos Bitas" off the shores of Wales during a nine day period in October 1978.

Both pumps, TK-4 and TK-5, were tested by the U.S. Coast Guard for use in the ADAPTS and NAVSEA systems. Both pumps performed adequately with ADAPTS with the TK-5 providing a higher discharge rate. The TK-5 performed well with the NAVSEA system. Tests were conducted with fresh water and No. 4 fuel oil.

Refer to Hazardous Chemical Pumps Tests, July 1980, by S.J. Rosenberg and R.F. Christensen of the U.S. Coast Guard.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Frank Mohn Fusa A/S
P.O. Box 10
N-5670 Fusa
Norway
Telephone (47) (055) 82100
Telex: 40417 a/b FRAFUN

In the United States:

Frank Mohn Houston, Inc.
Sales and Service Office
P.O. Box 1586
La Porte, Texas 77571
U.S.A.
Telephone (713) 471-7920
Telex: 230-790108 a/b FRAMO LAPT

In Canada:

Maritime Hydraulics and Machinery
10 Akerly Blvd., Suite 15-17
Dartmouth, N.S.
B3B 1J4
Canada
Telephone (902) 861-4885

OTHER DATA – Frank Mohn alşo manufactures an Emergency Off-Loading System consisting of the TK-5 and TK-6 pumps (specially designed for large volume transfer of crude oil or high viscosity fluids) contained in two containers, complete with powerpack, hoses, and fuel tanks. This system is presently (1984) used by the Canadian Coast Guard (contact Ed Gauthier, Canadian Coast Guard: Emergencies, telephone (613) 992-9743, Ottawa, Ontario, Canada).

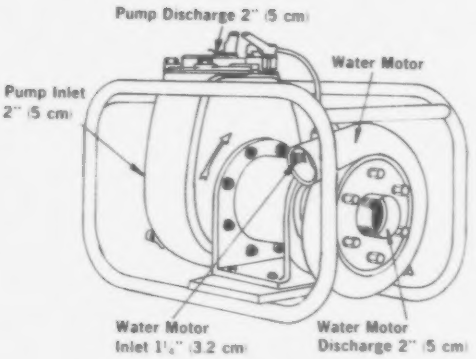
References: Manufacturer's Literature; Rosenberg, S.J. and R.F. Christensen.

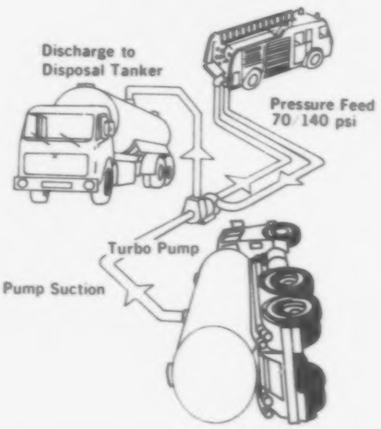
PRODUCT GILKES 3.25 F PORTABLE EMERGENCY TURBO PUMP **No. 102**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – A lightweight, portable, flame-proof pump for handling volatile liquids which is powered by a turbo water motor.


Pump Discharge 2" (5 cm)
Water Motor
Pump Inlet 2" (5 cm)
Water Motor Inlet 1¼" (3.2 cm)
Water Motor Discharge 2" (5 cm)



OPERATING PRINCIPLE – The pump is powered by a reaction-type water motor (Francis principle) in which a circular impeller is rotated by the force of water entering the casing from an external pressurized water source, such as a fire truck or water main.

PHYSICAL SPECIFICATIONS –

Water Motor:

Gilkes 3.25 Francis Water Motor
4 bhp @ 3 600 rpm with 5.8 L/s of water @ 965 kPa pressure
Constructed of bronze with stainless steel shaft and fittings for fresh or salt water operations. Water motor inlet: 32 mm (1.25 in) B.S.P.; water motor outlet 51 mm (2 in) B.S.P.

Self-Priming Pump:

Output of 11.0 L/s @ discharge pressure of 117 kPa
Constructed of cast iron or stainless steel, depending on liquids to be handled. Pump inlet and discharge flange-51mm (2 in) B.S.P.
Carrying Bar
Overall Weight: 45.5 kg (100 lb)

OPERATING SPECIFICATIONS –

Turbo pump performance with different turbine conditions:

Turbine - 5.8 L/s @ 965 kPa can pump 11.0 L/s @ 12.2 m head - 4.7 L/s @ 30.5 m head
Turbine 4.9 L/s @ 690 kPa can pump 10.4 L/s @ 6.1 m head - 0.3 L/s @ 27.4 m head
Turbine - 3.5 L/s @ 345 kPa can pump 6.3 L/s @ 1.5 m head - 0.6 L/s @ 12.2 m head

STATUS OF DEVELOPMENT AND USAGE – The portable emergency turbo pump is applicable to refineries, general chemical sites, firefighters, tankers (highway, railroad, water) and emergency response teams.

PERFORMANCE – Use of this pump in response to hazardous chemical spills has not been documented.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Gilkes Inc.
1902 Highway 146
P.O. Box 628
Seabrook, TX 77586
U.S.A.
Telephone (713) 474-3016
Telex: 792-653

No Canadian Distributor

OTHER DATA – None obtained.

PRODUCT INGERSOLL-RAND GRP PUMPS **No. 103**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – Single-stage, end-suction, centrifugal pump constructed of glass-reinforced plastic.

OPERATING PRINCIPLE – All pumps operate on the centrifugal principle. See Entry No. 96.

PHYSICAL SPECIFICATIONS –

Pump Size mm (in)	Suction mm (in)	Discharge mm (in)	Weight kg (lb)	Width mm (in)	Length mm (in)
38 x 25 x 152 (1.5 x 1 x 6)	38 (1.5)	25 (1)	27.2 (60)	273 (11)	445 (17.5)
76 x 51 x 152 (3 x 2 x 6)	76 (3)	51 (2)	29.5 (65)	273 (11)	445 (17.5)
76 x 38 x 203 (3 x 1.5 x 8)	76 (3)	38 (1.5)	79.4 (175)	413 (16)	597 (23.5)
102 x 76 x 203 (4 x 3 x 8)	102 (4)	76 (3)	–	–	597 (23.5)
76 x 38 x 254 (3 x 1.5 x 10)	76 (3)	38 (1.5)	–	–	597 (23.5)
102 x 76 x 254 (4 x 3 x 10)	102 (4)	76 (3)	–	–	597 (23.5)
152 x 102 x 254 (6 x 4 x 10)	152 (4)	102 (4)	–	–	597 (23.5)

All wetted parts are made of glass-reinforced vinyl ester of polymer material.
(Note: Heights variable, depending on bedplate.)

OPERATING SPECIFICATIONS – GRP pump capacities range from 0 to 189 L/s, with heads up to 50 m @ 1800 rpm and from 0 to 44 L/s, with heads up to 100 m @ 3600 rpm.

STATUS OF DEVELOPMENT AND USAGE – Commonly used in corrosive chemical services in the chemical processing industries.

PERFORMANCE – GRP pumps are claimed to transfer the following chemicals:

Acetic Acid
Aluminum Chloride
Aluminum Sulphate
Ammonium Chloride
Ammonium Nitrate
Ammonium Phosphate
Copper Sulphate
Cyclohexane
Dichlorobenzene
Ethanol
Ethyl Benzene
Ethylene
Ethylene Glycol
Ferric Chloride
Formaldehyde
Hydrogen Chloride/Acid
Hydrogen Peroxide
Isopropanol
Latex
Ammonium Sulphate
Barium Sulphate
Benzene
Borax
Boric Acid
Calcium Carbonate
Magnesium Hydroxide
n-Butanol
n-Hexane
Nitric Acid
Phenol
Phosphoric Acid
Potash (Potassium Chloride)
Potassium Carbonate
Potassium Sulphate
Propylene Glycols
Sodium Carbonate
Sodium Chlorate
Sodium Chloride
Calcium Chloride
Calcium Hypochlorite
Calcium Oxide/Hydroxide
Carbon Disulphide
Carbon Tetrachloride
Chlorine
Sodium Dichromate
Sodium Hydroxide
Sodium Hypochlorite
Sodium Nitrate
Sodium Sulphate
Sodium Sulphite
Styrene (Monomer)
Sulphuric Acid (and Oleum)
Toluene
Xylenes
Zinc Chloride
Zinc Sulphate

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Ingersoll-Rand Company
Pump Group
No. 1 Pump Place
Allentown, PA 18105
U.S.A.
Telephone (215) 776-6100

In Canada: Head Office:

Ingersoll-Rand Canada, Inc.
630 Dorchester Blvd. West
Montreal, Quebec
Canada
H3B 1S6
Telephone (514) 879-3000

In Canada: Branch Offices:

225 Lesmill Rd.
Don Mills, Ontario
M3B 2V1
Telephone (416) 445-4470

333-11th Ave. SW
Calgary, Alta.
T2R 0C7
Telephone (403) 261-8652

444 Barrydowne Rd
Sudbury, Ont.
P3A 3T3
Telephone (705) 566-4121

1695 Main St.
Vancouver, B.C.
V6A 2W7
Telephone (604) 879-0556

OTHER DATA – No other information obtained.

Reference: Manufacturer's Literature.

PRODUCT KONTRO SEAL-LESS PUMPS **No. 104**

APPLICABILITY	Gas	Liquid			Solid		
		Sol	Fl	Sk	Sol	Fl	Sk
		*	*	*			

DESCRIPTION – A line of seal-less magnetic-drive pumps constructed from corrosion-resistant materials.

OPERATING PRINCIPLE – The impellers of these centrifugal pumps are driven by a rotating magnet (magnetic induction) outside of the impeller casing, thus eliminating the need for a drive shaft seal.

PHYSICAL SPECIFICATIONS –

Model	Materials of Construction Wetted Parts	Drive Shaft Bearings
DC (Chemical Service)	316 stainless steel	pure fused carbon or filled Teflon
HS (High Capability)	Carbon steel, Stainless steel, Alloy 20, Monel, Hastelloy, Nickel	pure fused carbon or filled Teflon
HS/HSP (High System Pressure)	Sames as HS except pump casing is Nimonic 90 (same chemical resistance as steel).	
HJ (Jacketted)	Carbon steel, Stainless steel, Alloy 20, Monel, Hastelloy, Nickel	N/A

Drive motor is a NEMA standard foot-mounted design.

OPERATING SPECIFICATIONS –

Model	Range of Flow Rates (L/s)	Maximum Total Dynamic Head (m)	Maximum Solids Content (by Weight)	Maximum Solids Size (μm)	Range of Operating Temperature (°C)	Maximum Pressure (kPa)
DC	0.03 to 6.3	91.4	1.5%	100	- 40 to 260	1 034
HS	0.03 to 94.7	91.4	1.5%	100	-212 to 399	2 068
HJ	0.03 to 94.7	91.4	1.5%	100	-212 to 399	2 068
HS/HSP	0.03 to 6.3	91.4	1.5%	100	- 40 to 260	34 474

STATUS OF DEVELOPMENT AND USAGE – Commercially available for corrosive acid or alkaline chemical transfer services in the chemical processing industries.

PERFORMANCE – The manufacturer claims the following chemicals or their solutions may be transferred by Kontro seal-less pumps if constructed of the appropriate materials.

ACIDS

- Acetic Acid
- Benzoic Acid
- Boric Acid
- Carbolic Acid
- Chlorosulphonic Acid
- Formic Acid
- Hydrobromic Acid
- Hydrochloric Acid
- Hydrocyanic Acid
- Lactic Acid
- Maleic Acid
- Nitric Acid
- Oxalic Acid
- Phosphoric Acid
- Phthalic Acid
- Sulphuric Acid

ALCOHOLS and GLYCOLS

- Butanol
- Diethyl Glycol
- Ethanol
- Glycol
- Isopropyl Alcohol
- Methanol
- Propanol
- Propylene Glycol

ALKALIS

- Ammonium Hydroxide
- Calcium Hypochlorite
- Ferric Hydroxide
- Potassium Hydroxide
- Sodium Hypochlorite
- Sodium Chlorite

HALOGENIDES

- Anhydrous Chlorine
- Carbon Tetrachloride
- Hydrogen Chloride
- Methyl Chloride
- Methylene Chloride
- Silicon Tetrachloride

NITROGEN & SULPHUR COMPOUNDS

- Anhydrous Ammonia
- Carbon Disulphide
- Sulphur Dioxide
- Triethanol Amine

HYDROCARBONS

- Acrylonitrile
- Amyl Acetate
- Benzene
- Butadiene
- Butane
- Chlorobenzene
- Chloroform
- Chloroprene
- Cyclohexane
- Dichlorobenzene
- Ethylene
- Furfural
- Hexane
- Methylene Dichloride
- Methyl Naphthalene
- Naphtha
- Naphthalene
- Pentane
- Phenol
- Phthalic Anhydride
- Polychlorinated Biphenyls
- Styrene
- Toluene
- Trichloroethylene
- Vinyl Acetate
- Vinyl Chloride Monomer
- Xylene

SALTS

- Aluminum Chloride
- Ammonium Chloride
- Ammonium Sulphate
- Calcium Chloride
- Copper Sulphate
- Ferrous Chloride
- Ferrous Sulphate
- Phosphorus Trichloride
- Phosphorus Oxychloride
- Potassium Chlorate
- Sodium Carbonate
- Sodium Chlorate
- Sodium Cyanide
- Sodium Nitrate
- Sodium Sulphate
- Zinc Chloride

OTHER CHEMICALS

- Acetaldehyde
- Acetic Anhydride
- Acetone
- Acrolein
- Ethylene Oxide
- Ethyl Ether
- Formaldehyde
- Hydrogen Peroxide
- Lead Acetate
- Mercuric Chloride
- Methacrylates
- Methyl Ethyl Ketone
- Mineral Oil
- Propylene Oxide
- Tetraethyl Lead
- Vegetable Oils
- Water, Boiler
- Water, Deionized
- Water, Demineralized
- Water, Heavy

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

The Kontro Company, Inc.
P.O. Box 30
450 West River Street
Orange, MA 01364
U.S.A.
Telephone (617) 544-2536

Distributor:

Technotherm Inc.
4916 rue Sherbrooke ouest
Montréal, Québec
H3Z 1H3
Telephone: (514) 483-3030

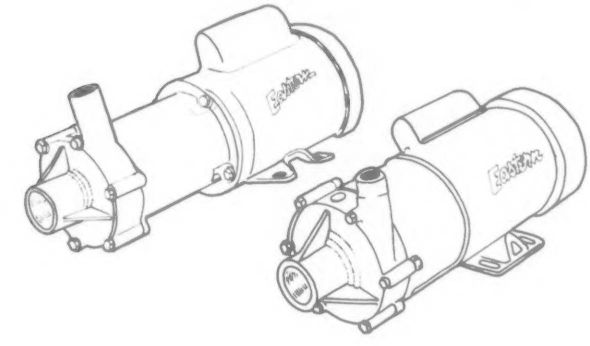
OTHER DATA – None obtained.

PRODUCT LFE MAGNETIC DRIVE PUMPS **No. 105**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – A line of seal-less, magnetic-drive pumps constructed from corrosion-resistant materials.



OPERATING PRINCIPLE – The impellers of these centrifugal pumps are driven by a rotating magnet (magnet induction) outside of the impeller casing, thus eliminating the need for a drive shaft seal.

PHYSICAL SPECIFICATIONS –

Model	Suction Size mm (in)	Discharge Size mm (in)	Power (hp)	Weight kg (lb)	Height mm (in)	Length mm (in)	Width mm (in)
MDH-32-G01/2	38 (1.5)	32 (1.3)	1	31.7 (70)	229 (9)	533 (21)	203 (8)
MDH 32-G03/4	38 (1.5)	32 (1.3)	1	31.7 (70)	229 (9)	559 (22)	229 (9)
MDH-25-G01/2	32 (1.3)	25 (1)	1/2	19.0 (42)	203 (8)	457 (18)	203 (8)
MDH-25-G03/4	32 (1.3)	25 (1)	1/2	19.0 (42)	203 (8)	533 (21)	267 (10.5)
MDH-80-G02	19 (0.7)	19 (0.7)	1/3	12.2 (27)	165 (6.5)	381 (15)	191 (7.5)
MDR-60T-G01/2	19 (0.7)	13 (0.5)	1/4	7.9 (17)	165 (6.5)	330 (13)	191 (7.5)
MDR-40T-G01/2	13 (0.5)	13 (0.5)	1/8	3.6 (8)	127 (5)	279 (11)	152 (6)
MDR-30T-G01/2	13 (0.5)	13 (0.5)	1/20	3.4 (7.5)	127 (5)	267 (10.5)	89 (3.5)
MD-15T-G01/2	13 (0.5)	10 (0.4)	1/20	3.4 (7.5)	127 (5)	267 (10.5)	89 (3.5)
MD-15A-G01/2	13 (0.5)	13 (0.5)	1/20	2.5 (5.5)	102 (4)	216 (18.5)	89 (3.5)
MD-6-G03/1	13 (0.5)	13 (0.5)	1/225	0.9 (2)	89 (3.5)	102 (4)	76 (3)
MDF-50	50 (1.9)	38 (1.5)	3 or 5	54.4 (120)	346 (13.6)	838 (33)	279 (11)
MDF-65	65 (2.6)	51 (2)	3	90.7 (200)	416 (16)	838 (33)	359 (14)
MDF-80	80 (3.5)	64 (2.5)	5	99.8 (220)	416 (16)	838 (33)	367 (14.5)

Materials of Construction

MDH, MDR, MD Series: Magnets encapsulated in polypropylene supported by an inert TFE bearing on a ceramic spindle.

MDR-30T/40T/50T/60T Series: Ultra pure alumina ceramic spindle.

MDF Series: Liquid ends construction of chemically inert fluoroplastic.

Casings: MDF-50: Polyvinylidene fluoride
MDF-65/80: Du Pont Tefzel

Spindles: Alumina ceramic (MDF-65/80) PTFE covered Hastelloy C (MDF-50)

Bearings: Alumina ceramic (MDF-50) or PTFE or carbon (MDF-6585)

O-Ring: Viton (EPR optional)

Thrust Ring: Ceramic/PTFE (MDF-50/65/80) or ceramic/carbon (MDF-65/80)

OPERATING SPECIFICATIONS –

Fluid Characteristics:

Temperature: MD, MDH Series 0° to 60°C
MDR Series: 0° to 82°C
MDF Series: 0° to 80°C

Kinematic Viscosity: MD, MDH, MDR Series: up to $3 \times 10^{-5}\ m^2/s$

Specific Gravity: MD, MDH, MDR Series: up to 1.3
MDF Series: up to 2.0

Capacities:

MD Series: up to 9.9 m head or 1.1 L/s
MDR Series: up to 9.4 m head or 1.1 L/s
MDH Series: up to 18.3 m head or 3.8 L/s
MDF Series: up to 32.0 m head or 11.4 L/s

STATUS OF DEVELOPMENT AND USAGE – Commonly used for corrosive acid or alkaline transfer services in the chemical processing industries.

PERFORMANCE –

MD, MDH and MDR Series can be used on acids, alkalis and some solvents.
MDF-50/65/80 series may be used for the following chemicals with the proper pump material selection.

Acetic Acid
Acetone
Aluminum Chloride
Bromine Water
Carbon Disulphide
Caustic Soda
Chromic Acid
Crude Petroleum
Ethyl Alcohol
Ferrous Chloride
Ferrous Sulphate
Hydrochloric Acid
Hydrogen Peroxide
Hydroiodic Acid
Mixture Acid
  (Sulphuric and Nitric)
Nickel Sulphate
Nitric Acid
Oxalic Acid
Phosphoric Acid
Photographic Developer
Photographic Fixative
Plating Solution (Chromium
  or Nickel)
Sodium Cyanide (sat.)
Sodium Hypochlorite (sat.)
Sulphuric Acid

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

LFE Corporation
Fluids Control Division
100 Skiff Street
Hamden, CT 06514
U.S.A.
Telephone (203) 281-8000

Distributor:

LFE Canada Limited
2774 Slough Street
Mississauga, Ontario
Canada
L4T 1G3
Telephone (416) 677-1103

OTHER DATA – None obtained.

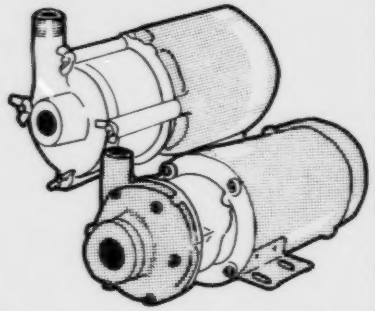
Reference: Manufacturer's Literature.

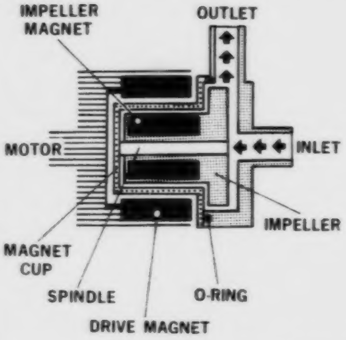
PRODUCT LITTLE GIANT MAGNET-DRIVEN CHEMICAL PUMPS No. 106

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – Magnetic-driven centrifugal pumps constructed from corrosion-resistant materials.





OPERATING PRINCIPLE – These centrifugal pumps have magnetic drives to separate the impeller from the drive mechanism.

PHYSICAL SPECIFICATIONS –

MD Series (Non-submersible)

Seal-less, magnetic drive.
Titanium shaft and thrust washer (most models).
Permanent ceramic (barium ferrite) magnet.
Glass-filled polypropylene pumping head and impeller with an uncoated ceramagnet "A"-type ceramic magnet.
Buna-N static O-ring.
Inlet: 13 mm (0.5 in) or 16 mm (0.6 in) depending on model.
Discharge: 13 mm (0.5 in) or 16 mm (0.6 in) depending on model.

MD-SC Series (Non-submersible)

Leak-proof, seal-less magnetic drive.
99.5% pure alumina ceramic shaft and thrust washers.
Glass-filled polypropylene pumping head and impeller with encapsulated magnet.
Buna-N O-ring.
Inlet: 13 mm (0.5 in), 19 mm (0.7 in) or 25 mm (1 in), depending on model.
Discharge: 25 mm (1 in).

MD-HC Series (Non-submersible)

Leak-proof, seal-less magnet drive.
99.5% pure alumina ceramic shaft and thrust washers.
Carbon Impeller Bushing - self lubricating, impervious to fluids.
Glass-filled Ryton pumping head and impeller with Ryton encapsulated magnet.
Metal motor mounting bracket (most models).
"TE" Models have totally enclosed fan-cooled motors.
Viton O-ring.

OPERATING SPECIFICATIONS –

MD Series

Fluid Temperature: up to 65°C
Fluid Specific Gravity: up to 1.1
Absolute Fluid Viscosity:
up to 20×10^{-3} Pa·s
Ambient Air Temperature:
up to 25°C
Operating Pressure:
up to 345 kPa

MD-SC Series

Fluid Temperature: up to 65°C
Fluid Specific Gravity: up to 1.1
Absolute Fluid Viscosity:
up to 20×10^{-3} Pa·s
Ambient Air Temperature:
up to 25°C
System Operating Pressure:
up to 345 kPa

MD-HC Series

May be run dry up to 8 hours
Fluid Temperature: up to 93°C
Fluid Specific Gravity: up to 1.1
Absolute Fluid Viscosity: up to 20×10^{-3} Pa·s
Ambient Air Temperature: up to 25°C

STATUS OF DEVELOPMENT AND USAGE – Commonly used in photographic, pharmaceutical or plating industries.

PERFORMANCE – Use of the Little Giant magnet driven chemical pumps in response to hazardous material spills has not been documented. A comprehensive chart rating the chemical effect of 490 chemicals on 31 materials used in the construction of pumps, including 316 stainless steel, Hastelloy C, polypropylene and Neoprene, is available from Little Giant.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Little Giant Pump Company
3810 North Tulsa St.
Oklahoma City, OK 73112
U.S.A.
Telephone (405) 947-2511
Telex 748-519

Distributor:

Ontor Limited
Customer Services
12 Leswyn Rd
Toronto, Ontario
Canada
M6A 1K3
Telephone (416) 781-5286

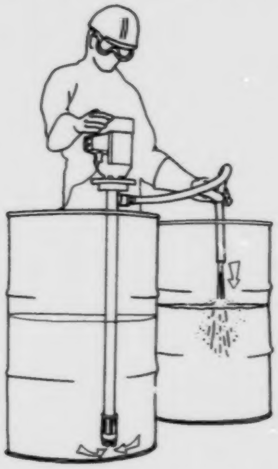
OTHER DATA – No other information obtained.

PRODUCT LUTZ DRUM PUMPS **No. 107**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – Drum pumps designed for transfer of corrosive chemicals.



OPERATING PRINCIPLE – Electricity or air drives the impellers of these centrifugal pumps.

PHYSICAL SPECIFICATIONS – All components (motors, pump tubes) are interchangeable.

Motors

	Electric				Air	
	B-3	B-4	B-5		4 GT	4 AL
Power (watts)	420	440	580	Air Pressure (kPa)	600	634 Air Pressure (kPa)
Voltage (v)	110	110	110	Air Pressure (psi)	87	92 Air Pressure (psi)
Cycle (Hz)	50	60	60	rpm	7500	7500
Weight (kg)	1.9	5.9	6.6		0.45	1.8
Comments	"Work -horse"	Heavy Duty	Extra Heavy Duty			High Volume

Electric motors B-4 and B-5 are equipped with thermal overload switches and mechanical resets.
All motors listed here are claimed to be suitable for hazardous duty.
Electric motors equipped with 4.9 m (16 ft) oil and acid-resistant cord.

Pump Tubes

Stainless Steel

38 mm (1.5 in) diameter
25 mm (1 in) friction-fit hose connection
Teflon impeller

Hastelloy C:

38 mm (1.5 in) diameter
25 mm (1 in) friction-fit hose connection
Teflon impeller
Mechanical seal constructed of ceramic Teflon with a Teflon oil seal.

Aluminum:

38 mm (1.5 in) diameter
25 mm (1 in) friction-fit hose connection
Teflon impeller
Mechanical seal constructed of carbon ceramic with a Teflon oil seal.

Polypropylene:

38 mm (1.5 in) diameter
25 mm (1 in) friction-fit hose connection
Teflon impeller

Tube Lengths available for:

Vats, Reactors: 119 cm (47 in)
55 U.S. gal drums: 86 cm (34 in)
Carboys: 68 cm (27 in)

SL Series Drum Pump

Stainless steel or polypropylene.
Mounted at bottom end of pump tube.
Patented Teflon sleeve protects pump shaft from corrosive materials.

OPERATING SPECIFICATIONS –

		ELECTRIC DRIVEN			AIR DRIVEN		
		B-3	B-4	B-5	4 GT	4 AL	SL Series
Maximum Kinematic Viscosity ($m^2/s \times 10^6$)		150	750	750	150	315	750
Maximum Specific Gravity		1.4	1.5	1.6	1.4	1.4	1.6
Maximum Head	m	7.9	8.8	11.6	5.5	8.8	14.6
	(ft)	(26)	(29)	(38)	(18)	(29)	(48)
Maximum Pump Rate	L/s	1.9	2.8	3.2	1.3	2.8	1.5
	(U.S. GPM)	(30)	(45)	(50)	(20)	(45)	(24)

STATUS OF DEVELOPMENT AND USAGE – Commercially available for transferring corrosive and other hazardous chemicals from drums, carboys, open tanks and small reactors.

PERFORMANCE – Contact manufacturer for a list of chemicals compatible with the Lutz Drum pumps. Recognizing that stainless steel, Hastelloy C and polypropylenes are materials commonly used to construct corrosion-resistant pumps and process equipment, Lutz Drum pumps appear to be suitable for most hazardous materials.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Lutz Pumps, Inc.
472 Armour Circle NE
Atlanta, GA 30324
U.S.A.
Telephone (404) 875-6686

Distributor:

John Vissers Sales Corporation
6481 Keele St., Unit 18
Concord, Ontario
Canada
L4K 1Z7
Telephone (416) 738-1555

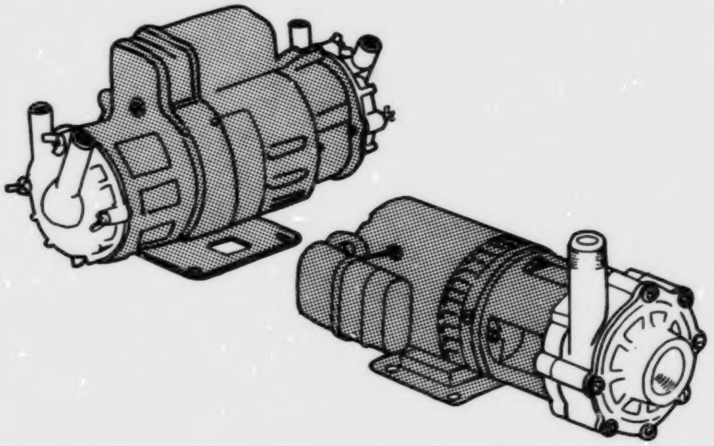
OTHER DATA – Other Lutz Drum Pump accessories are available such as mixing tubes, strainers, and barrel adaptors (to hold pump stationary).

PRODUCT MARCH CHEMICAL PUMPS **No. 108**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – Magnetic seal-less and conventional drive pumps with components designed to withstand corrosive chemicals.



OPERATING PRINCIPLE – Centrifugal pumps - see Entry No. 96.

PHYSICAL SPECIFICATIONS –

Epoxy Clad Pumps (Submersible)

19 Submersible Models
Up to 1/8 hp
Wetted materials in submersibles include:
- polypropylene, Delrin, Cycolac, Nylon, Noryl and Ceramic
- "O" rings include: Viton, Buna N, Silicon and ethylene propylene

Motor housings are epoxy-coated.

Pumps for Mildly Corrosive Applications (Non-submersible)

12 Models
Up to 1/8 hp
Wetted materials include:
- polypropylene, nylon, Delrin, Noryl, Viton, Buna N and ethylene propylene

Chemical Pumps for Highly Corrosive Applications

6 Models
Up to 7-1/2 hp
Wetted materials include:
Ryton, polypropylene, stainless steel, Hastelloy "C", Chemloy, carbon and ceramic compositions
"O" ring materials are Buna N, Teflon and Viton
Motors available in a variety of housings including totally enclosed, drip-proof, explosion-proof and chemical duty.

OPERATING SPECIFICATIONS –

Epoxy Clad Pumps (Submersibles)

Flow Rate: up to 1.1 L/s (0.3 U.S. gal)
Head: up to 9.8 m (32 ft)

Chemical Pumps for Mildly Corrosive Applications (Non-submersible)

Flow Rate: up to 1.1 L/s (0.3 U.S. gal)
Head: up to 32 m (105 ft)
Solution Temperature: up to 88°C (190°F)
Specific Gravity: up to 2.0
Kinematic Viscosity: up to 87.6 m^2/s (943 ft^2/s)
Internal Pressure: up to 345 kPa

Chemical Pumps for Highly Corrosive Applications

Flow Rate: up to 12.6 L/s (3.3 U.S. gal)
Head: up to 38.4 m (126 ft)
Solution Temperature: up to + 260°C (500°F)
Specific Gravity: up to 2.8
Kinematic Viscosity: up to 132 m^2/s (1420 ft^2/s)
Internal Pressure: up to 3447 kPa

STATUS OF DEVELOPMENT AND USAGE – Commonly used for corrosive acid or alkaline chemical transfer in the chemical processing industries.

PERFORMANCE – The manufacturer claims March chemical pumps, when constructed from appropriate materials, are compatible with the following chemicals:

Acetic Acid
Acetone
Alum
Aluminum
Aluminum Chloride
Aluminum Fluoride
Aluminum Sulphate
Ammonia
Ammonium Chloride
Ammonium Fluoride
Ammonium Hydroxide
Ammonium Nitrate
Ammonium Persulphate
Ammonium Sulphate
Ammonium Sulphide
Amyl Alcohol
Barium Chloride
Barium Hydroxide
Barium Sulphate
Benzaldehyde
Benzene
Benzene Sulphonic Acid
Boric Acid
Brine
Bromine Liquid
Butane
Butyl Acetate
Butyl Alcohol
Calcium Chloride
Calcium Hydroxide
Calcium Hypochlorite
Calcium Nitrate
Calcium Sulphate
Carbon Tetrachloride
Chlorine
Chromic Acid
Citric Acid
Cyclohexane
Detergents
Diesel Fuel
Dowtherm
Ether
Ethyl Alcohol
Ethylene Glycol
Ferric Chloride
Fluoboric Acid
Fluosilicic Acid
Formaldehyde
Formic Acid
Freons
Gasoline
Hydrochloric Acid
Hydrofluoric Acid
Hydrogen Peroxide
Kerosene
Ketones
Methyl Alcohol
Methyl Ethyl Ketone
Methylene Chloride
Mineral Oil
Naphthalene
Nitric Acid
Nitrobenzene
Oils
Oleum
Perchloroethylene
Phenol
Phosphoric Acid
Plating Solutions
Potassium Hydroxide
Propyl Alcohol
Propylene Glycol
Silicone Oil
Hexane
Hydrobromic Acid
Sodium Chloride
Sodium Hypochlorite
Sodium Hydroxide
Sulphamic Acid
Sulphuric Acid
Toluene
Trichloroethylene
Turpentine
Water, deionized
Xylene

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

March Manufacturing, Inc.
1819 Pickwick Ave.
Glenview, IL 60025
U.S.A.
Telephone (312) 729-5300

SMS Limited

3015 Kennedy Road
Agincourt, Ontario
Canada
M1V 1E7
Telephone (416) 291-9648

Distributor:

Miller Plastics
19 Advance Road
Toronto, Ontario
Canada
M8Z 2S6
Telephone (413) 233-1143

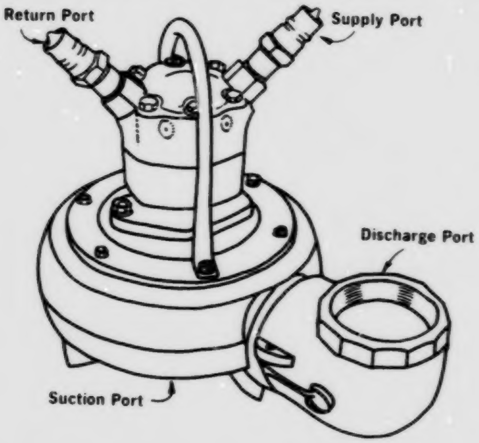
OTHER DATA – No other information obtained.

Reference: Manufacturer's Literature.

PRODUCT MARCO U101 CAPSULPUMP **No. 109**

APPLICABILITY	Gas	Liquid			Solid		
		Sol	Fl	Sk	Sol	Fl	Sk
		*	*	*			

DESCRIPTION – A compact, submersible, centrifugal, high volume transfer pump.



OPERATING PRINCIPLE – Centrifugal pump hydraulically driven by a portable power unit.

PHYSICAL SPECIFICATIONS –

Pump dimensions: Approximately 460 mm (18 in) high by 356 mm (14 in) dia.; 578 mm (23 in) long with the discharge port.
Suction and discharge ports: 102 mm (4 in) dia.
Hydraulic fluid supply and return ports: 19 mm (0.7 in)
Dry weight: 36.4 kg (80 lb)
Aluminum casing (bronze available on special order)
Carbon steel housing for hydraulic motor
Carbon steel or bronze impeller

OPERATING SPECIFICATIONS –

Submersible: drop directly into liquid.
Can run dry without harm to pump.
Can pass materials up to 102 mm (4 in) dia.
Can be cleaned without disassembly.

For a discharge head of 12.2 m (40 ft):

	Hydraulic Input Requirements		
Capacity L/s (U.S. GPM)	Oil Flow L/s (U.S. GPM)	Pressure kPa (psi)	Power (hp)
25.2 (400)	1.1 (18)	7 860 (1 140)	14
54.2 (860)	1.3 (23)	12 411 (1 800)	28.4

STATUS OF DEVELOPMENT AND USAGE – The Marco U101 Capsulpump was designed for applications such as fish transfer, petrochemical off-loading, agricultural irrigation and tailings removal, construction site and sump hole dewatering, oil spill recovery, and ship salvage.

PERFORMANCE — Use of the Marco U101 Capsulpump for hazardous chemical spills (acids, bases, solvents) has not been documented. The user must investigate the compatibility of aluminum and steel and the hose material with the hazardous materials which are anticipated to contact the pump.

AVAILABILITY AND COMMERCIAL INFORMATION —

Manufacturer:	Distributor:
Marine Construction & Design Co. 2300 West Commodore Way Seattle, WA 98199 U.S.A. Telephone (206) 285-3200 Telex: 32-0098 Cable: MARCO	Gourock Industries 24 Akerley Blvd. Dartmouth, N.S. B3B 1J3 Telephone (902) 465-7599 Telex: 31424

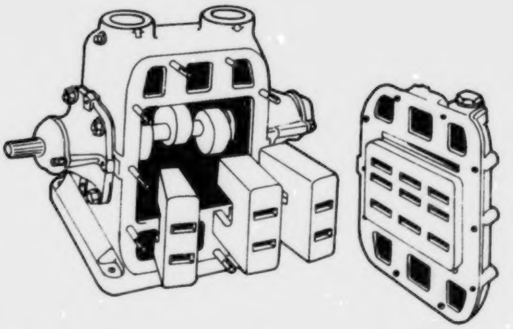
OTHER DATA — None obtained.

PRODUCT MEGATOR SLIDING-SHOE PUMPS **No. 110**

APPLICABILITY

Gas	Liquid Sol	Liquid Fl	Liquid Sk	Solid Sol	Solid Fl	Solid Sk
	*	*	*			

DESCRIPTION – A positive displacement "sliding shoe" pump capable of passing particulate and solids up to 4.8 mm (3/16 in) in diameter.



OPERATING PRINCIPLE – The pumping mechanism is comprised of three or more "shoes", or plastic displacement chambers, each of which is reciprocated vertically by an eccentric rotor disc inside. Parts in the face of each shoe register alternately with the suction and discharge ports in the port plate, thus inducing a pumping action. (Sliding-shoe pumps are protected by Megator patents in the U.S.A. and elsewhere.)

PHYSICAL SPECIFICATIONS –

		Maximum Total			Pump			
Model	Capacity L/s (U.S. gal)	Head m (ft)	Suction Lift m (ft)	Motor (hp)	rpm	Length mm (in)	Width mm (in)	Height mm (in)
L 75	0.41 (0.11)	30.5 (100)	7.0 (23)	0.75	1730	648 (25.5)	203 (8)	293 (11.5)
L100	0.82 (0.22)	30.5 (100)	7.0 (23)	0.75	1730	730 (28)	267 (10.5)	363 (14)
L125	1.1 (0.30)	30.5 (100)	7.0 (23)	1	1150	770 (30)	305 (12)	425 (16)
L150	2.3 (0.60)	30.5 (100)	7.0 (23)	3	1150	885 (35)	305 (12)	495 (19)
L200	3.8 (1)	30.5 (100)	7.0 (23)	5	1150	1045 (41)	356 (14)	590 (23)
L300	8.2 (2.2)	30.5 (100)	6.1 (20)	7.5	865	1380 (54)	420 (16.5)	780 (30.7)
L400	16.4 (4)	30.5 (100)	6.1 (20)	15	865	1710 (67)	470 (18.5)	815 (32)
H 75	0.47 (0.12)	61.0 (200)	7.0 (23)	0.75	1730	720 (28)	267 (10.5)	293 (11.5)
		69.4 (228)	1					
H100	0.95 (0.25)	45.7 (150)	7.0 (23)	1	1730	778 (30)	305 (12)	363 (14)
		69.4 (228)	1.5					
H125	1.1 (0.30)	54.9 (180)	7.0 (23)	2	1150	915 (36)	305 (12)	425 (16)
		69.4 (228)	3					
H150	2.5 (0.66)	45.7 (150)	7.0 (23)	3	1150	1045 (41)	356 (14)	508 (20)
		69.4 (228)	5					
H200	3.4 (0.90)	61.0 (200)	6.4 (21)	5	865	1090 (43)	407 (16)	590 (23)
		69.4 (228)	7.5					
H300	5.7 (1.5)	54.9 (180)	6.4 (21)	7.5	865	1360 (53.5)	457 (18)	780 (30.7)
		69.4 (228)	10					
H400	11.3 (3)	54.9 (180)	6.4 (21)	15	865	1760 (69)	470 (18.5)	815 (32)
		69.4 (228)	20					

These specifications refer to direct-coupled pumps with electric motors (mounted on a base plate) pumping clear water. Belt-driven and close-coupled belt-driven are also available. Compressed air and hydraulic motors and gasoline engines are also applicable. Stationary, skid-mounted and fully mobile configurations have been developed.

Materials of Construction:

Shoes: Plastic with synthetic rubber lining.
Casing: Cast iron or bronze
Port Plate: Precipitation hardened stainless steel.
Rotor: Nitralloy or precipitation hardened stainless steel.
Shaft Seals: Carbon face ring and bronze seat (Tungsten carbide face rings and seats are available as an option for abrasive liquids).
Relief valve must be fitted to pump by owner.
Optional oil-immersed thermostatically-controlled electric heater available for cold weather operation.

OPERATING SPECIFICATIONS –

Self-priming
Can run safely for short periods of time with completely dry suction.
Operating Temperature: up to 38°C (100°F)
Capacities (see PHYSICAL SPECIFICATIONS)
Can pass solid particles up to 4.8 mm (3/16 in) diameter.

STATUS OF DEVELOPMENT AND USAGE – Originally designed for mine dewatering, the sliding-shoe pump is also used in the food industry and in marine environments.

PERFORMANCE – Megator claims the following chemicals can be transferred by the sliding-shoe pump:

- Alcohol
- Acetic Acid (up to 50%)
- Ammonium Chloride
- Ammonium Nitrate (10%)
- Ammonium Sulphate (10%)
- Aniline
- Beer
- Benzoic Acid
- Boric Acid (5%)
- Brine
- Calcium Bisulphide
- Calcium Chloride
- Calcium Nitrate
- Castor Oil
- Kerosene
- Lactic Acid (Dilute)
- Linseed Oil
- Magnesium Sulphate
- Methanol
- Methylated Spirit
- Molasses
- Mustard
- Oil, Cutting
- Oil, Diesel
- Oil, Insulating
- Oil, Lubricating
- Oil, Olive, Palm, Pine
- Oil, Quenching
- Oil, Sperm
- Oil, Tractor
- Oleic Acid
- Caustic Potash
  (Potassium Hydroxide)
- Caustic Soda
  (Sodium Hydroxide)
- Chocolate
- Cider
- Citric Acid
- Copper Sulphate
- Cyanide solutions
- Dextrine
- Epsom Salts
  (Magnesium Sulphate)
- Ethylene Glycol
- Ferric Sulphate
- Paraffin
- Pectin
- Pentane
- Pickle (Brine)
- Plating Solutions
- Polyvinyl Acetate
- Emulsion (PVA)
- Potash (Potassium Chloride)
- Potassium Cyanide
- Potassium Hydroxide
- Potassium Nitrate
- Potassium Sulphate
- Printer's Ink
- Sea Water
- Soda Ash
  (Sodium Carbonate)
- Sodium Bicarbonate
- Ferrous Sulphate
- Formaldehyde
- Freon
- Fruit Juices
- Furfural
- Gelatine
- Glauber's Salt
  (Sodium Sulphate)
- Glycerine
- Gum
- Heptane
- Hydraulic Oils
- Hydrogen Sulphide
- Ink
- Sodium Chloride
- Sodium Cyanide
- Sodium Hydroxide
- Sodium Nitrate
- Sodium Silicate
- Sodium Sulphate
- Sodium Sulphide
- Starch
- Sugar Syrup
- Tanning Liquors
- Turpentine
- Whey
- Whiskey
- White Spirit
- Wine
- Wort
- Yeast

The following chemicals are not compatible with the Megator sliding-shoe pump:

- Acetone
- Alum (Aluminum Sulphate)
- Benzaldehyde
- Benzine
- Bromine Water
- Bromobenzene
- Butyl Acetate
- Butyl Alcohol
- Calcium Hypochlorite
- Carbon Tetrachloride
- Chlorobenzene
- Chloroform
- Chromic Acid
- Cresylic Acid
- Curde Oil Solid Sludge
- Ethyl Acetate
- Ethyl Mercaptan
- Ethylene Chloride
- Ferric Chloride
- Ferrous Chloride
- Formic Acid
- Furan
- Gasoline
- Hexaldehyde
- Hydrochloric Acid
- Hydrofluoric Acid
- Hydrofluosilicic Acid
- Iodine
- Latex
- Lead Acetate (Sugar of Lead)
- Lead Oxide
- Milk
- Nitric Acid
- Oxalic Acid
- Petrol
- Phenol (Carbolic Acid)
- Phosphoric Acid
- Potassium Dichromate
- Resin Size (e.g., Bewoid)
- Sodium Hypochlorite
- Tar
- Toluene
- Trichloroethylene
- Xylene
- Zinc Chloride

The Megator L150 was identified as a good pump for oil spill cleanup because of its suction lift, cold tolerance, and ease of maintenance and handling.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Megator Corporation
562 Alpha Dr.
Pittsburgh, PA 15238
U.S.A.
Telephone (412) 963-9200
Contact: Mr. L.F. Beatty

Distributor:

M.S.E. Engineering Systems, Ltd.
265 Canartic Drive
Downsview, Ontario
Canada
M3J 2N7
Telephone (416) 661-5646

OTHER DATA – Megator also manufactures the "Dolphin" floating suction strainer which prevents suction hoses from drawing sediment from the bottom of a basin, river or tank. The company also markets oil spill skimmers of their own design which operate in conjunction with the sliding shoe pump and which may have application to some hazardous materials (see Entry No. 36).

References: Manufacturer's Literature.

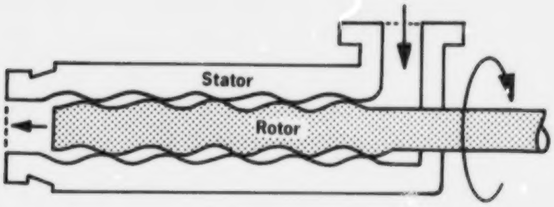
Solsberg, L.B. and W.F. Purves, "Pumps for Oil Spill Cleanup", EPS Report EPS 4-EC-78-3, Environment Canada (1978).

PRODUCT MOYNO PROGRESSING CAVITY PUMPS **No. 111**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – Various models of progressing cavity process pumps.



OPERATING PRINCIPLE – A screw-shaped rotor rotates inside a cylinder. As it rotates, fluid moves through the length of the cylinder by progressing cavities formed between the rotor and walls of the cylinder (stator).

PHYSICAL SPECIFICATIONS – Three models of process pumps are available:

	Centennial	Industrial	Quick Disassembly
Number of Models Available	40	Many	30
Length mm (in)	1083 to 3216 (42 5/8 to 126 5/8)	444 to 1798 (17 1/2 to 70 13/16)	775 to 1697 (30 1/2 to 66 13/16)
Height mm (in)	292 to 597 (11 1/2 to 23 1/2)	149 to 356 (5 7/8 to 14)	194 to 400 (7 5/8 to 15 3/4)
Weight kg (lb)	145 to 1227 (320 to 2700)	10 to 169 (22 to 372)	22.7 to 250 (50 to 550)
Motor (hp)	1/4 to 250	1/6 to 15	1/4 to 15
Materials of Construction	Stator: Special elastomers and natural rubber		Stainless steel, Teflon, Viton, natural rubber, EPDM, Buna-N
	Rotor: Steel, chrome-plated (option: stainless steel, special requests)		Stainless steel
	Drive Shaft: Steel, chromium-plated		N/A

Options available for Centennial and Industrial pumps:
"Open Throat" hopper for easier feeding (8 sizes available)
"Bridge Breaker" for breaking semi-dry material (8 models)

OPERATING SPECIFICATIONS –

	Centennial	Industrial	Quick Disassembly
Capacities L/s (U.S. GPM)	0.31 to 63 (5 to 1000)	up to 28.4 (450)	up to 18.9 (300)
Pressures kPa (psi)	up to 3100 (450)	up to 6200 (900)	N/A

Quick Disassembly Pumps will process particles up to 25 mm (1 in.) in diameter and temperatures up to 149°C (300°F).

STATUS OF DEVELOPMENT AND USAGE – Progressing cavity pumps are used to transfer slurries and viscous fluids in chemical processing and waste treatment.

PERFORMANCE – The following chemicals have been transferred by Moyno pumps:

Acetic Acid
Acetone
Benzene
Calcium Hypochlorite
Carbon Disulphide
Carbon Tetrachloride
Cellulose Acetate
Chromic Acid
Copper Sulphate
Ethyl Alcohol
Ferric Chloride
Furfural
Glycerine
Hydrochloric Acid
Hydrofluosilicic Acid
Hydrogen Peroxide
Hydrogen Sulphide
Methanol
Methyl Chloride
Nitric Acid
Phosphoric Acid
Potassium Carbonate
Potassium Hydroxide
Sodium Hydroxide
Sodium Nitrate
Toluene
Zinc Chloride

Progressive cavity pumps have a limited tolerance for solid particles - damaging the stator causes loss of its close tolerance with the rotor (which is critical for efficient pump operation). Tests using the Moyno 1L10H showed it could pass 1.9 cm (0.7 in) lengths of wooden dowel and crushed ice chunks for short periods of time.

STATUS OF DEVELOPMENT AND USAGE –

Manufacturer:

Robbins & Myers, Inc.
Fluids Handling Div. (Moyno Pumps)
1934 Clark Blvd.
Springfield, OH 45501
U.S.A.
Telephone (513) 327-3553

Distributor:

Robbins & Myers Company of Canada Ltd.
Moyno Pump Div.
P.O. Box 280
Brantford, Ontario
Canada
N3T 5N6
Telephone (519) 752-5447

OTHER DATA – None obtained.

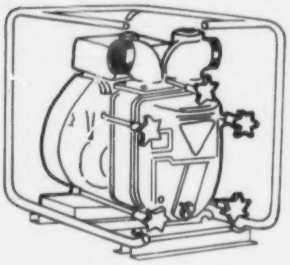
References: Manufacturer's Literature; Environment Canada, "Evaluation of Pumps and Separators for Arctic Oil Spill Cleanup", by Western Hydraulic Laboratories Ltd., B.C. EPS 4-EC-79-3 (April, 1979).

PRODUCT MULTIQUIP QP STAINLESS STEEL PUMPS **No. 112**

APPLICABILITY

Gas	Liquid Sol	Liquid Fl	Liquid Sk	Solid Sol	Solid Fl	Solid Sk
	*	*	*			

DESCRIPTION – Medium capacity, stainless steel centrifugal pumps.



Reference: Multiquip Inc. Bulletin SSP-800.

OPERATING PRINCIPLE – These centrifugal pumps are powered by gasoline or diesel engines or electric motors.

PHYSICAL SPECIFICATIONS –

Type	Model	Suction x Discharge Size cm (in)	Engine/Motor	hp	Weight kg (lb)
Self-Priming Centrifugal Pumps - Engine Driven	QP-SS20	5 x 5 (2 x 2)	Wisc. Robin EY-18-3W	4.6	56 (123)
	QP-SS20D	5 x 5 (2 x 2)	B&S Farymann	7.1	101 (222)
	QP-SS30	7.6 x 7.6 (3 x 3)	Wisc. Robin EY-18-3W	4.6	58 (127)
	QP-SS30D	7.6 x 7.6 (3 x 3)	B&S Farymann	7.1	103 (226)
Self-Priming Centrifugal Pumps - Electric Motor Driven	QP-SS20M	5 x 5 (2 x 2)	2HP (1.5kW) 220/440 V 3 ϕ 60 Hz TEFC	2.0	52 (114)
	QP-SS30M	7.6 x 7.6 (3 x 3)	3HP (2.2 kW) 220/440 V 3 ϕ 60 Hz TEFC	3.0	61 (134)
Self-Priming Centrifugal Pumps - Pedestal Mounted	QP-SS20P	5 x 5 (2 x 2)	Requires 2 hp @ 3450 rpm	–	31 (68)
	QP-SS30P	7.6 x 7.6 (3 x 3)	Requires 3 hp @ 3450 rpm	–	31 (68)
Self-Priming Trash & Sewage Pumps - Engine Driven	QP-SS20T	5 x 5 (2 x 2)	Wisc. Robin EY-18-3W	4.6	57 (125)
	QP-SS20TD	5 x 5 (2 x 2)	B&S Farymann	7.1	102 (225)
	QP-SS31T	7.6 x 7.6 (3 x 3)	Wisc. Robin EY-18-3W	4.6	58 (127)
Self-Priming Trash & Sewage Pumps - Electric Motor Driven	QP-SS20TM	5 x 5 (2 x 2)	3HP (2.2 kW) 220/440 V 3 ϕ 60 Hz TEFC	3.0	64 (141)
	QP-SS31TM	7.6 x 7.6 (3 x 3)	3HP (2.2 kW) 220/440 V 3 ϕ 60 Hz TEFC	3.0	76 (167)
Self-Priming Trash & Sewage Pumps - Pedestal Mounted	QP-SS20TP	5 x 5 (2 x 2)	Requires 3 hp @ 3450 rpm	–	33 (72)
	QP-SS31TP	7.6 x 7.6 (3 x 3)	Requires 3 hp @ 3450 rpm	–	34 (75)

OPERATING SPECIFICATIONS –

Model	Pump Capacity (at minimum head)
All 51 mm (2 in)	approx 11.0 L/s (175 U.S. GPM)
All 76 mm (3 in)	approx 18.9 L/s (300 U.S. GPM)

Self-priming
Fast repairs (access to pump housing by turning five knobs)
Suspended Particle Tolerance:
Self-priming centrifugals - up to one quarter of the diameter of the suction line.
Trash or Sewage Pumps - up to one half the diameter of the suction line.

STATUS OF DEVELOPMENT AND USAGE – Commercially available for marine, petrochemical, agrochemical, and chemical process applications.

PERFORMANCE – Multiquip claims the QP Stainless Steel Pumps may be used for a variety of materials including:

petroleum distillates of low to medium viscosity
alkalis to a pH value of 13.5 (chlorines, vinyl chlorides)
acids to a pH value of 3.0 (muriatic, acetic, ascorbic)
ammonium and potassium-based fertilizers
naphtha and ethylene-based insecticides and herbicides
fresh or salt water containing particulates up to 3.8 mm (1.5) dia.
abrasive-laden cutting, drilling and cooling compounds
ammonias, glycols and benzoates
juices, syrups, saps and liquors

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Multiquip Inc.
19600 Wilmington Ave.
Carson, CA 90746
U.S.A.
Telephone (213) 537-3700
Telex 691574

Mailing Address: P.O. Box 6254
Carson, CA 90749
U.S.A.

Distributor:

Polyquip Inc.
4420 Poirier Blvd.
St. Laurent, Québec
Canada
H4R 2C5
Telephone (514) 334-6855

OTHER DATA – None obtained.

PRODUCT SERFILCO CENTRIFUGAL CHEMICAL PUMPS **No. 113**

APPLICABILITY	Gas	Liquid			Solid		
		Sol	Fl	Sk	Sol	Fl	Sk
		*	*	*			

DESCRIPTION – Centrifugal pumps in various configurations constructed of chemical-resistant materials.

OPERATING PRINCIPLE – All pumps operate on the centrifugal principle. See Entry No. 96.

PHYSICAL SPECIFICATIONS –

Sump Pumps:

- "Series A or B"
  Casing of CPVC
  Ceramic Liner
  Rulon or Graphite Ring
  Ethylene Propylene "O" Ring
  Discharge: 19 to 51 mm (0.7 to 2 in)
  Motors: 1/2 to 15 hp
- "Series HB"
  Suction Casing of CPVC
  Rulon Bearing
  Fluoride-resistant Ceramic Sleeve
  Enclosed Impeller
  Suction: 51 mm (2 in)
  Discharge: 38 mm (1.5 in)
  Motors: 1 to 7 1/2 hp
- "Series E"
  CPVC Shaft Casing
  Ethylene Propylene or Viton "O" Ring
  Suction: 19 to 51 mm (0.7 to 2 in)
  Discharge: 10 to 32 mm (0.4 to 1.3 in)
  Motors: 1/2 to 12 hp

Horizontal Pumps:

- "Series HE"
  Pump Sleeve and Casing are CPVC
  "O" Ring and Mechanical Seal are available in EPR/carbon/ceramic, Viton/carbon/ceramic, and Viton/carbon/SF ceramic
  Suction: 51 mm (2 in)
  Discharge: 38 mm (1.5 in)
  Motors: 1 1/2 to 7 1/2 hp

Kynar Chemical Pumps

Kynar Construction
Viton Bellows
Suction: 38 mm (1.5 in)
Discharge: 38 mm (1.5 in)
Motors: 3/4 to 3 hp

Self-Priming Pumps

All major pumps parts are 30% glass-filled PBT polyester.
Viton and 316 stainless steel mechanical seal.
Suction: 38 mm (1.5 in)
Discharge: 38 mm (1.5 in)
Motors: 1/2 to 3 hp

Roll-Flex Pumps

No shaft or seal
Self-priming
Wetted parts are CPVC and vinyl tubing
Suction/Discharge: 5 mm or 13 mm (0.20 to 0.5 in)
Motors: 1/15 or 1/4 hp

Flexible Impeller Pumps

Bakelite or Epoxy
Neoprene Impeller
Lip type or external carbon/ceramic mechanical seal
316 stainless or corrosion-resistant steel shaft
Suction/Discharge: 16 to 25 mm (0.63 to 1 in)
Motors: 1/3 to 1 hp

Also available with Viton impellers and titanium or Hastelloy B pump shafts.

Magnetic Coupled Pumps

"Series A"
Available in CPVC, polypropylene or Tefzel with polypropylene encapsulated magnet and ethylene propylene "O" ring.
Suction/Discharge: 16 mm (0.6 in)
Motor: 1/12 hp

"Series B"
Available in polypropylene or CPVC with polypropylene encapsulated magnet and ethylene polypropylene "O" ring; Teflon with Teflon encapsulated magnet and Vinton "O" ring; Tefzel with Tefzel encapsulated magnet and ethylene propylene "O" ring.
Suction/Discharge: 19 mm (0.7 in)
Motors: 1/6 or 1/2 hp

"Series T"
Two pumps on opposite ends of a double shaft
Available in CPVC or polypropylene, with polypropylene encapsulated magnet and ethylene propylene "O" ring.
Suction/Discharge: 13 to 19 mm (0.5 to 0.7 in)
Motors: 1/4 or 1/2 hp

"Series AS"
Submersible with self-contained motor
Polypropylene with polypropylene encapsulated magnet and ethylene propylene "O" ring.
Suction/Discharge: 16 mm (0.6 in)
Motors: 1/15 hp

"Series D"
Available in G/F PP (Glass-Filled Polypropylene) with Ryton bushing and G/F PP liner; G/F PP or Ryton with Ryton bushing and liner; 316 stainless steel with Ryton bushing and 316 SS liner.
Suction/Discharge from 25 x 13 mm to 38 x 25 mm
(1 x 0.5 in to 1.5 x 1 in)
Motors: 1/4 to 3/4 hp

Drum Pump

Available in 316 stainless steel with ceramic and Teflon seal; polypropylene with Hastelloy C shaft, and ceramic and graphite seal; aluminum with ceramic and Teflon seal.
Impeller is Tefzel
Discharge: 25 mm (1 in)
Motor: 1/2 hp

OPERATING SPECIFICATIONS – The following chemicals may be transferred using Serfilco chemical pumps:

Acetaldehyde
Acetic Acid
Acetic Anhydride
Acetone
Aluminum Chloride
Ammonium Chloride
Ammonium Hydroxide
Ammonium Nitrate
Amyl Acetate
Aniline
Benzene
Benzoic Acid
Butyl Alcohol
Butylamine
Cadmium Cyanide
Calcium Hypochlorite
Carbon Tetrachloride
Chlorobenzene
Chloroform
Chlorosulphonic Acid
Chromic Acid
Copper Chloride
Copper Sulphate
Cresol
Cyclohexane
Ethyl Acetate
Ethyl Alcohol
Ethylene Dichloride
Ethylene Glycol
Ferric Chloride
Formaldehyde
Furfural
Glycerine
Hexane
Hydrochloric Acid
Hydrofluoric Acid
Hydrogen Peroxide
Lead Acetate
Methyl Chloride
Methyl Ethyl Ketone
Nitric Acid
Phenol
Phosphoric Acid
Potassium Carbonate
Potassium Cyanide
Potassium Dichromate
Potassium Hydroxide
Sodium Hypochlorite
Sodium Nitrate
Sulphuric Acid
Toluene
Trichloroethylene
Xylene
Zinc Chloride

STATUS OF DEVELOPMENT AND USAGE – Commercially available for use in the chemical processing industries.

PERFORMANCE – The use of Serfilco chemical pumps in response to hazardous material spills has not been documented.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Serfilco
1234 Depot Street
Glenview, IL 60025
U.S.A.
Telephone (312) 998-9300

Distributor:

John Vissers Sales Corporation
8481 Keel St., Unit 18
Concord, Ontario
Canada
L4K 1Z7
Telephone (416) 738-1555

OTHER DATA – None obtained.

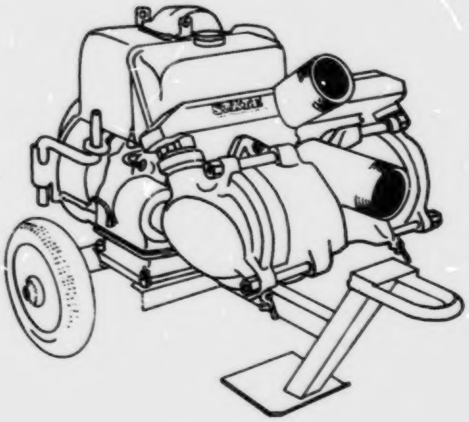
Reference: Manufacturer's Literature.

PRODUCT SPATE INDUCED FLOW PUMP **No. 114**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION — A portable wheel-mounted reciprocating construction pump.



OPERATING PRINCIPLE — An oscillating rubber impeller drives the liquid to be transferred on the forward stroke and bends to allow the fluid to continue flowing on the return stroke. This inertial flow during the return stroke produces flow up to two and a half times the actual swept volume of the pump cylinders.

PHYSICAL SPECIFICATIONS —

Dimensions and Weight

	AA1 Diesel Rope Starting	Electric 380/440v 3phase	Pump Unit Only
Length*	32" (82 cm)	32" (82 cm)	13 1/2" (34.5 cm)
Height	24" (61 cm)	24" (61 cm)	13 1/2" (34.5 cm)
Width	24" (61 cm)	24" (61 cm)	20 1/4" (51.5 cm)
Weight	193 lb (88 kg)	149 lb (68 kg)	54 lb (25 kg)

* Add 1" (2.5 cm) for Handle-starting

Materials of Construction

Casing: sea water resistant die cast aluminum/silicon alloy
Seals and Valves: synthetic or natural rubber
"O" Ring: Viton rubber

Motors - Direct-coupled Petter AA1 diesel or T.E.F.C. electric.

Fittings - 76 mm (3 in) friction-fit hose nipples.

OPERATING SPECIFICATIONS –

Site Performance Figures

Maximum Pump Output	8.8 L/s (140 U.S. gpm)
Maximum Combined Head	39.6 m (130 ft)
Maximum Discharge Head	30.5 m (100 ft)
Maximum Suction Lift	9.1 m (30 ft)
Maximum Self-priming Lift	8.8 m (29 ft)
Air Pressure delivery	482 kPa (70 psi)
Air Pumping capacity	3.8 L/s (8 cfm)

	L/s	Lift m (ft)	Discharge Head m (ft)
Typical Output:	5.5	2 (6.5)	8 (26)
	3.0	8 (26)	2 (6.5)

STATUS OF DEVELOPMENT AND USAGE – The SPATE is commercially available for construction, industrial and marine applications, such as dewatering excavations, high pressure washing, and oil spill cleanup. The pump is also capable of moderate air compression for inflating tires, rubber boats, etc.

PERFORMANCE – The SPATE pump has been used by the Canadian Coast Guard for oil spill cleanup.

A 1978 EPS report found the SPATE to be "well suited for high viscosity and high suction lift (oil) cleanup applications".

The compatibility of the SPATE pump with hazardous materials is limited by the chemical resistance of the aluminum casing and rubber valves. It is designed to primarily handle sea water, fresh water, oils and oil/water mixtures.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

William R. Selwood Ltd.
Chandler's Ford, Eastleigh
Hants SO5 3ZL
U.K.
Telephone 0421-5-2981
Telex 47683

Distributor:

Peacock Inc.
1158 Aerowood Dr.
Mississauga, Ontario
Canada
L4W 1Y5
Telephone (416) 625-7100

Other offices in Calgary, Edmonton and Vancouver.

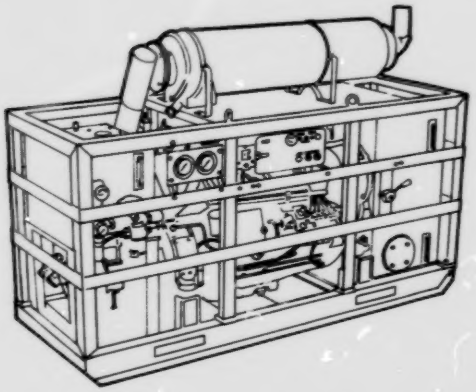
OTHER DATA – A Tire Inflator Kit is available for conversion of the SPATE to a compressor (max. 482 kPa (70 psi)).

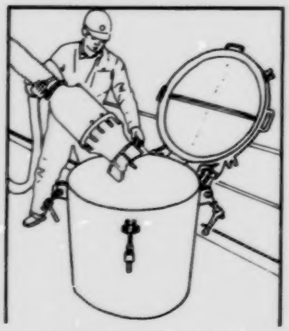
PRODUCT THUNE-EUREKA PORTABLE SUBMERSIBLE PUMPS **No. 115**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – A self-contained, portable, high capacity pump system consisting of a pump and power pack.





OPERATING PRINCIPLE – The pump is a single-stage centrifugal type coupled with a high pressure hydraulic axial piston motor powered by an external power pack.

PHYSICAL SPECIFICATIONS –

	Pumps	
	CCN 100	CCN 150
Diameter mm (in)	270 (10.6)	305 (12)
Height mm (in)	600 (23.6)	830 (32.6)
Weight kg (lb)	60 (132)	110 (242.5)

Pump casing manufactured from nickel, aluminum, bronze or stainless steel.
Two skid-mounted, diesel engine hydraulic power packs are available (50 and 100 kW).

OPERATING SPECIFICATIONS –

	Capacity (water) L/s)	
Head m (ft)	CCN 100	CCN 150
20 (65.6)	65	167
40 (131)	60	140
60 (197)	47	90
80 (262)	28	55

STATUS OF DEVELOPMENT AND USAGE – Marketed as a portable unloading system for emergency or auxiliary pumping of liquids (water, viscous oils) from cargo tanks.

PERFORMANCE – The CCN 150 was tested by the U.S. Coast Guard for use with the ADAPTS or NAVSEA Off-Loading systems. The liquids pumped were fresh water and No. 4 Fuel Oil. It was concluded that the pump performed well with the NAVSEA system.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:	North American Representative:
Thune-Eureka A/S P.O. Box 38 N-3401 Lier Norway International Phone (47) (3) 850400 Telex 18608 THUNE N	Marine Pollution Control 8631 West Jefferson Detroit, MI 48209 U.S.A. Telephone (313) 849-2333

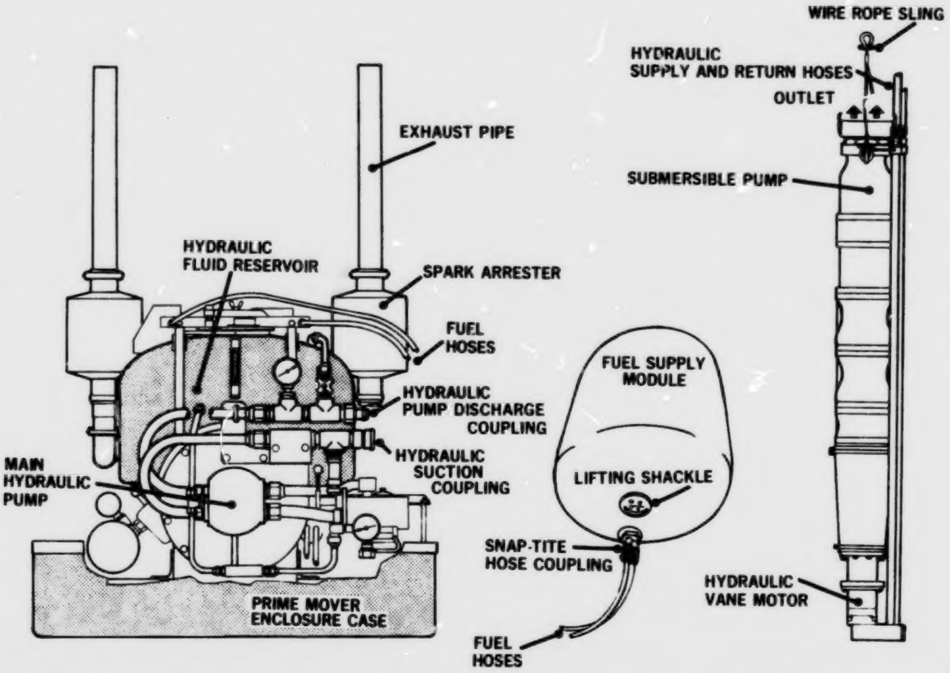
OTHER DATA – None obtained.

Reference: Rosenberg, S.J. and R.F. Christensen, Hazardous Chemical Pump Tests, U.S. Coast Guard (July, 1980).

PRODUCT U.S. COAST GUARD ADAPTS PUMPING SYSTEM **No. 116**

APPLICABILITY	Gas	Liquid			Solid		
		Sol	Fl	Sk	Sol	Fl	Sk
		*	*	*			

DESCRIPTION – A portable high capacity off-loading system for disabled ocean vessels consisting of a diesel-hydraulic power unit ("prime mover") and submersible pumps.



OPERATING PRINCIPLE – The power unit, centrifugal pump and hosing are lowered to the deck of a disabled vessel and the cargo off-loaded to another ship (lightering vessel) or appropriate temporary storage container.

PHYSICAL SPECIFICATIONS –

Type 3 prime mover capacity:	2.5 L/s (40 U.S. GPM) @ 20 670 kPa (3000 psi)
Some pumps available:	- Byron Jackson Submersible Centrifugal Pumps - Framo TK4, TK5 Submersibles - Sloan Trash Pump

Note: Specific technical information for the most recent (May, 1984) Type 3 ADAPTS system was not available at the time of printing of this survey. Consult the manufacturer listed under "AVAILABILITY AND COMMERCIAL INFORMATION".

OPERATING SPECIFICATIONS – Consult manufacturer listed under "AVAILABILITY AND COMMERCIAL INFORMATION" for specific technical information. ADAPTS used by the U.S. Coast Guard are equipped with a variety of pumps, hoses and fittings for compatibility with most hazardous materials, including oils.

STATUS OF DEVELOPMENT AND USAGE – ADAPTS (Air Deliverable Anti-Pollution Transfer System) was first developed by the U.S. Coast Guard between 1969 and 1971. (Refer to final report, "Development of the Air Deliverable Anti-Pollution Transfer System (ADAPTS)", by CDR Robert J. Ketchel, United States Coast Guard, Pollution Control Branch, August 6, 1971 (Project No. 714101/001), available from National Technical Information Service (NTIS), Springfield, VA, 22151, U.S.A.

ADAPTS is now delivered directly to disabled vessels instead of parachute deployment into the ocean area near the disabled vessel. Development of flexible temporary storage containers as part of ADAPTS was discontinued in the late 1970's. Now consists of submersible pumps and diesel-hydraulic power unit, similar to the FRAMO and Thune-Eureka systems (also described in this section).

PERFORMANCE – ADAPTS has been used successfully by U.S. Coast Guard Strike Teams. Contact the following offices for first-hand discussion of the performance of the ADAPTS:

U.S. Coast Guard Strike Teams:

Atlantic Region	Pacific Region	Gulf Region
(919) 338-3941	(415) 883-3311	(601) 688-2380

AVAILABILITY AND COMMERCIAL INFORMATION –

ADAPTS is manufactured for the
U.S. Coast Guard by:

Fluid Automation, Inc.
3415 Cori Rd.
Jacksonville, FL 32217
U.S.A.
Telephone (904) 268-3141
Contact: Doug Spence, President
Phil Parker

In the U.S. Coast Guard:

CDR. John Clay
ADAPTS Project Officer
Applied Technology Division
U.S. Coast Guard Headquarters
Washington, DC 20591
U.S.A.
Telephone (202) 755-4874

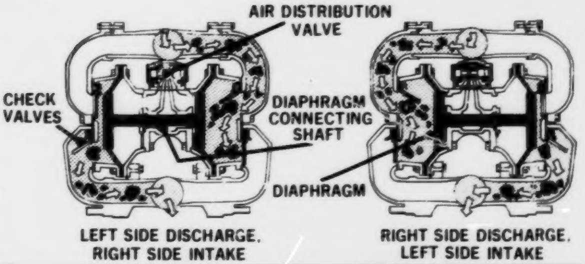
OTHER DATA – The Canadian Coast Guard uses an ADAPTS under the name STOPTS (Self-contained Tanker Off-loading Petroleum Transfer System). Contact Ed Gauthier, Canadian Coast Guard Emergencies Office in Ottawa, Ontario, Telephone (613) 992-2380 for technical information regarding STOPTS.

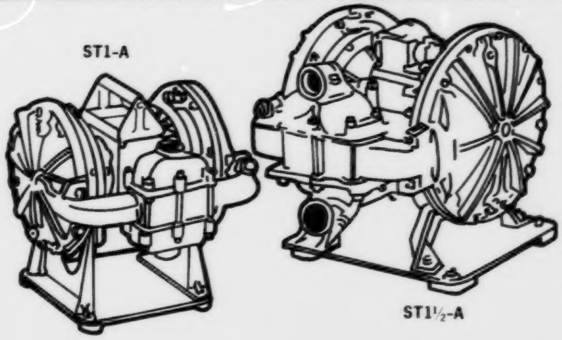
PRODUCT WARREN RUPP V.I.P. SANDPIPER PUMPS **No. 117**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – Air-powered double diaphragm pump with chemical-resistant Teflon ball-valves and diaphragms.


AIR DISTRIBUTION VALVE
CHECK VALVES
DIAPHRAGM CONNECTING SHAFT
DIAPHRAGM
LEFT SIDE DISCHARGE, RIGHT SIDE INTAKE
RIGHT SIDE DISCHARGE, LEFT SIDE INTAKE



OPERATING PRINCIPLE – Two diaphragms are joined at their centers by a shaft. Air pressure alternately applied against each diaphragm creates discharge and intake by respectively compressing and expanding the volume of the diaphragm chambers. Check valves - two in each chamber - control the intake and discharge.

PHYSICAL SPECIFICATIONS –

Dimensions and Weight

Model	ST1-A		ST1 1/2-A
Intake and Discharge	25 mm	(1 in)	38 mm (1.5 in)
Airline Connection	6.4 mm	(0.25 in)	13 mm (0.5 in)
Width	356 mm	(14 in)	414 mm (16 in)
Length	368 mm	(14.5 in)	470 mm (18.5 in)
Height	375 mm	(15 in)	470 mm (18.5 in)
Weight (Aluminum Model)	18 kg	(40 lb)	N/A

- Teflon diaphragms and ball valves.
- Wetted metal parts constructed of 380 die-cast aluminum, 356-T6 aluminum, cast iron, stainless steel or Hastelloy alloy C.

OPERATING SPECIFICATIONS –

Can pass solids up to 6.4 mm (0.25 in) in diameter.
Can run dry without damage to pump.
Can be used completely submerged.
Self-priming.
Fluid Temperatures: up to 100°C (121°C with appropriate materials).
Air Pressure required: up to 862 kPa.
Pump Capacities: ST1-A - up to 1.9 L/s
ST1 1/2-A - up to 5.7 L/s

STATUS OF DEVELOPMENT AND USAGE – Commercially available for many pumping applications, including hazardous environments where air power eliminates explosion and fire hazards.

PERFORMANCE – Sandpiper V.I.P.'s (Virtually Impervious Pumps) are claimed to be compatible with the following chemicals:

Acetic Acid
Acetone
Amines
Ammonia (Anhydrous)
Ammonia (Liquid)
Amyl Acetate
Asphalt
Benzene
Benzyl Alcohol
Benzyl Chloride
Bromine
Butyl Acetate
Butyl Cellusolve
Carbon Bisulphide
Carbon Tetrachloride
Chlorine
Chlorobenzene
Chlorosulphonic Acid
Chromic Acid
Cresol (Cresylic Acid)
Dioctyl Phthalate
Dowtherm
Ethyl Acetate
Ethyl Chloride
Ethyl Ether
Ethylene Dichloride
Furfural
Lacquer
Ketone
Lacquer Solvents
Methyl Ethyl Ketone
Mineral Spirits
Naphthalene
Nitric Acid
Oleic Acid
Plating Solution
Styrene
Sulphuric Acid
Toluene
Trichlorethylene
V M & P Naphtha
Xylene

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

The Warren Rupp Company
800 North Main Street
P.O. Box 1568
Mansfield, OH 44901
U.S.A.
Telephone (419) 524-8388

Distributor:

The Warren Rupp Company
1057 Orcades Crescent
Mississauga, Ontario
Canada
L4Y 2E7
Telephone (416) 279-5186

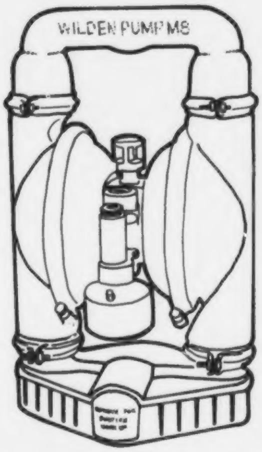
OTHER DATA – Warren Rupp also manufactures Sandpiper pumps with flap-type or ball-type check valves from a variety of materials. Flap valves allow passage of near pipe sized solids. Models SA2-A and SA3-A have been tested with oils by Environment Canada. Refer to Environmental Protection Service Technology Development Reports EPS 4-EC-78-3, "Pumps for Oil Spill Cleanup" (for SA2-A) and EPS 4-EC-79-3, "Evaluation of Pumps and Separators for Arctic Oil Spill Cleanup" (for SA3-A).

Reference: Manufacturer's Literature.

PRODUCT WILDEN AIR-OPERATED DIAPHRAGM PUMPS **No. 118**

APPLICABILITY	Gas	Liquid			Solid		
		Sol	Fl	Sk	Sol	Fl	Sk
		*	*	*			

DESCRIPTION – Submersible air-operated, double-acting diaphragm pumps.



OPERATING PRINCIPLE – Two flexible diaphragms joined by a common shaft simultaneously enlarge and contract pump cavities under the force of compressed air to yield a uniform pumping action.

PHYSICAL SPECIFICATIONS –

Model	M2	M4	M8	M15
Height mm (in)	267 (10 1/2)	457 (18)	667 (26 1/4)	832 (32 3/4)
Length mm (in)	178 (7)	340 (13 3/8)	400 (15 3/4)	508 (20)
Width mm (in)	267 (10 1/2)	362 (14 1/4)	308 (12 1/8)	419 (16 1/2)
Weight kg (lb)				
Aluminum	10 (22)	15.9 (35)	32.7 (72)	54.5 (120)
Iron or Stainless	N/A	23.6 (52)	58.2 (128)	97.7 (215)
Inlet/Discharge mm (in) (N.P.T.)	25 / 19 (1 / 3/4)	38 / 32 (1 1/2 / 1 1/4)	51 / 51 (2 / 2)	76 / 76 (3 / 3)

Materials of Construction:

Body - Aluminum, (epoxy coated optional), cast iron, 316 stainless steel, Hastelloy C.
Diaphragms and Ball Valves - neoprene, Buna N, Nordel, Viton, Teflon

OPERATING SPECIFICATIONS –

Pump Capacities (air supply of 18.9 L/s (40 scfm) @ 689 kPa (100 psi):

Model	M4	M8	M15
Water Discharge			
L/s	2.2	1.7	1.6
(U.S. gpm)	(35)	(27)	(25)
Discharge Head			
m	42.6	62.5	68.5
(ft)	(140)	(205)	(225)
Max. Solid Size			
mm	4.8	6.4	9.5
(in)	(3/16)	(1/4)	(3/8)

STATUS OF DEVELOPMENT AND USAGE – Commercially available for application in the food processing industry, paint manufacturing, well drilling, waste treatment, barge and tanker stripping, brewing construction, refineries and chemical process industries.

PERFORMANCE – Test results of pump comparisons are available from Wilden on request.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Wilden Pump and Equipment Co.
22069 VanBuren St.
Colton, CA 92324
U.S.A.
Telephone (714) 783-0621
Telex 676-452

Mandem
8550 Delmeade Rd.
Montreal, Québec
Canada
H4A 1L7
Telephone (514) 342-9233

Distributor:

York Fluid Controls Ltd.
2 Westwin Court
Brampton, Ontario
L6T 4T5
Telephone (416) 454-4013

OTHER DATA – None obtained.

Reference: Wilden Pump & Engineering Co. Brochure R5-76.

PRODUCT BUSCH VACUUM PUMP **No. 119**

APPLICABILITY

Gas Sol	Liquid Fl	Sk	Sol	Solid Fl	Sk
*					

DESCRIPTION — A line of multi-vane vacuum pumps for solvent and corrosive vapours.

OPERATING PRINCIPLE — Vapours are compressed from the discharge port of the pump cylinder by the action of impellers rotating on an eccentrically-mounted drive shaft. The cylinder is lubricated by an oil delivery system. The oil is ejected with the discharge vapours in the form of a mist which can be collected by an oil mist eliminator.

PHYSICAL SPECIFICATIONS —

R5 Series

Direct Drive
Single Impeller
Standard and Super Models Available
Can be used as a compressor up to 100 kPa with appropriate options.

Model	010	016	025	040	063
Inlet mm (in)	19 (0.7)	19 (0.7)	31.8 (1.3)	31.8 (1.3)	31.8 (1.3)
Weight kg (lb)	2.9 (46)	25.9 (57)	35.8 (79)	45.8 (101)	55.8 (123)
Power hp	0.75 0.75		1.5	2	3

Huckepack Series

Dual Impeller
Optional All-Ductile Iron Construction
Optional Self-Contained Radiator Cooling System

Model	429	433	437	441	445
Inlet mm (in)	50.8 (2)	50.8 (2)	50.8 (2)	76.2 (3)	152.4 (6)
Shipping Weight kg/lb					
-002	249.4 (550)	371.9 (820)	589.6 (1300)	612.2 (1350)	1496.6 (3200)
-014	281.2 (620)	394.6 (870)	634.9 (1400)	793.7 (1750)	1542.0 (3400)
Power hp	10	15	20	25	4

MONOVAC Series

Belt Driven
Single Impeller
Pumps are water-cooled
Non-metallic vanes
Teflon exhaust check valve

Model	216-002	225-002	240-002	263-002
Inlet mm (in)	51 (2)	51 (2)	51 (2)	51 (2)
Weight kg (lb)	158.7 (350)	235.8 (520)	362.8 (800)	530.6 (1170)
Power (hp)	10	15	20	25

OPERATING SPECIFICATIONS –

R5 Series:

Model	010	016	025	040	063	100	160	250	400	630
Free Air Displacement (m^3/min)	0.17	0.23	0.57	0.79	1.16	1.78	3.31	4.93	8.50	12.18
End Vacuum										
Super (kPa)	101	101	101	101	101	101	101	101	101	101
Standard (kPa)	99	99	99	99	99	99	99	99	99	99

HUCKEPACK Series:

Model	429	433	437	441	445
Free Air Displacement (m^3/min)	3.54	5.66	8.78	14.16	22.09
End Vacuum (kPa)	0.067	0.067	0.067	0.067	0.067

MONOVAC Series:

Model	216-002	225-002	240-002	263-002
Free Air Displacement (m^3/min)	3.54	5.66	8.78	14.16
End Vacuum (kPa)	6.66	6.66	6.66	6.66

STATUS OF DEVELOPMENT AND USAGE – Vacuum pumps are available for applications such as meat packing, distillation, plastic molding and deodorizing vegetable oils. Use in hazardous material spill scenarios has not been documented.

PERFORMANCE –

Compatible with vapours of:

Water
Alcohols
Aromatics
Aliphatics
Ketones
Chlorinated Hydrocarbons
Creosote
Toluene
Isobutylene
Dibutylparacresol
Ethyl Benzene
Benzene
Hexane
Dimethyl Cyclate
Methylene Chloride
Hydrochloric Acid
Amino Acid
Methanol
Diisobutylamine
Vinyl Chloride
Ethylene Diamine
Tetrahydrofuran
Methanol
Phenol
Acetone
Carbon Tetrachloride
Sulphur Dioxide
Ammonia
Catechol

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Busch Inc.
4974 Holland Rd
Virginia Beach, VA 23462
U.S.A.
Telephone (804) 497-8976

Distributor:

Canadian Air Compressor
1875 boul. Industriel
Laval, Québec
H7S 1P5
Telephone (514) 334-5810

OTHER DATA – The manufacturer should be consulted when developing a vapour recovery system which incorporates Busch vacuum pumps.

4.3 Transfer Hoses

PRODUCT ACID, CHEMICAL HOSES - GENERAL LISTING **No. 120**

Note: A broader commercial availability of transfer hoses exists with applicability to hazardous materials than is indicated by Entries No. 121, 122 and 123 which follow. The main purpose of this general listing is to present contact information for Canadian companies and, to a lesser extent, U.S. firms fabricating such equipment.

APPLICABILITY	Gas	Liquid			Solid		
		Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*	*	*	*	*

DESCRIPTION – Transfer hoses fabricated from natural and/or synthetic materials designed to withstand specific chemicals and acids including petroleum products, dry materials, vapours, etc.

OPERATING PRINCIPLE – Hoses are used in conjunction with pumps to either effect the initial pickup of spilled materials or transfer substances already collected.

PHYSICAL SPECIFICATIONS – Consult individual manufacturers. The customer should inquire as to the material type(s) of hose, its flexibility, internal diameter, length, weight, appropriate fittings (i.e., connectors), reinforcement, application (including whether used for suction or discharge, specific chemical) etc., Teflon, Hypalon, Viton, PVC, pure gum, rubber metal and other plastic hoses are sold.

OPERATING SPECIFICATIONS – Also consult manufacturer. Usage should be specified so that the hose is compatible with the material being transferred, ambient temperature, and the temperature of the substance of concern. Weight per unit length, flexibility, operating pressure and chemical versatility are other operational concerns.

STATUS OF DEVELOPMENT AND USAGE – Commercially available products. Fabricated to customer specifications or sold as standard hardware for a wide variety of applications.

PERFORMANCE – Not separately documented for spills of hazardous materials although used for that purpose and the in-plant transfer or other prescribed movement of various chemical substances.

AVAILABILITY AND COMMERCIAL INFORMATION –

In Canada, contact the following companies (these are manufacturers unless otherwise indicated):

Aeroquip (Canada) Inc.
287 Bridgeland Avenue
Toronto, Ont.
M6A 1Z7
Telephone (416) 781-5261

B.F. Goodrich Canada Inc.
(See Entry No. 121)
409 Weber Street W.
Kitchener, Ont.
N3G 4J5

City Industrial Sales Corp.
5937 Dixie Road
Mississauga, Ont.
L4W 1E8
Telephone (416) 677-1360

Epton Industries (See Entry No. 121)
521 King St. W.
Kitchener, Ontario
N2G 1C5
Telephone (519) 744-6530

Flexaust Canada Ltd.
Div. of Callaham Mining Corp.
P.O. Box 536
Whitby Industrial Park
Whitby, Ontario
L1N 5V3
Telephone (416) 668-8818

Gates Canada Inc. (See Entry No. 122)
P.O. Box 310
Brantford, Ontario
N3T 5W6

Goodall Rubber Co. of Canada Ltd.
(See Entry No. 123)
1160 Fewster Drive
Mississauga, Ontario
L4W 1A1
Telephone (416) 629-1624

Goodyear Canada Inc.
21 Four Seasons Place
Islington, Ontario M9B 6G2
Telephone (416) 626-4611

HP Power Drives Ltd. (wholesaler)
1299 Island
Montreal, Quebec
H3K 2N4
Telephone (514) 933-4261

Hose Technology Inc. (distributor)
7-1031 Hubrey Rd.
London, Ont.
N6N 1B4
Telephone (519) 685-3070

IPM Supplies Ltd.
4500 Shepherd Ave E.
Scarborough, Ont.
M1S 3R6
Telephone (416) 298-0494

Industrial Sales Ltd. (distributor)
2825 Botham
Montreal, Quebec
H4S 1H8
Telephone (514) 336-2252

Johnston Industrial Plastics Ltd.
20 Fleeceline Rd.
Toronto, Ont.
M8V 2K3
Telephone (416) 255-7706

Kingston Eric Sales Ltd.
150 Bentworth Ave.
Toronto, Ontario
M6A 1P7
Telephone (416) 789-2691

Lawjack Equipment Ltd. (wholesaler)
5235 Henri Bourassa
Montreal, Quebec
H4R 1B8
Telephone (514) 334-0252

Nevtro Sales Ltd. (wholesaler)
720 Quebec
London, Ontario
N5Y 1W8
Telephone (519) 451-0930

Omniflex Industrial Sales Ltd. (distributor)
18-225 Sheldon Drive
Cambridge, Ontario
N1T 1A1
Telephone (519) 653-2713

Ontario Hose Specialists Ltd. - agent
1455 Britannia Rd. E.
Mississauga, Ontario
L4W 1C7
Telephone (416) 677-0113

Ontario Rubber
19 Constellation Court
Rexdale, Ontario
M9W 1K4
Telephone (416) 675-5630

Pantek Industrial Products - wholesaler
758 Halpern Avenue
Dorval, Quebec
H9P 1G6
Telephone (514) 631-9130

Source: 1983 Fraser's Canadian Trade Directory

Representative U.S. companies include the following:

Abbott Rubber Co.
2482 Delta Lane
Elk Grove Village, IL 60007
Telephone (312) 595-7090

Amazon Hose & Rubber Co.
132 N. Jefferson Street
Chicago, IL 60606
Telephone (312) 372-4073

Dynacraft
Dept. 82TR
P.O. Box 1518
Bellevue, WA 98009
Telephone (206) 455-6550

Empex Industrial Hose
6929 Paramount Blvd.
N. Long Beach, CA 90805
Telephone (213) 636-9703

Atlanta Rubber Incorporated
690-B Eleventh St. N.W.
Atlanta, GA 30318
Telephone (404) 875-7731

Capital Rubber Corporation
1512 East Algonquin Road
Arlington Heights, IL 60005
Telephone (312) 640-6966

QIP Equipment Ltd. - wholesaler
3185 Halpern St.
Montreal, Quebec
H4S 1P5
Telephone (514) 337-2661

Resinol Plastic Industries Ltd.
2567 De Miniac
St. Laurent, Quebec
H4S 1E5
Telephone (514) 336-5044

Uniroyal Ltd.
Industrial Products Division
1806 Notre Dame E
Montreal, Quebec
H2K 2N3

Vibro-Flo Inc.
2470 Lucknow Drive - Unit 15
Mississauga, Ontario
L5S 1J9
Telephone (416) 677-0918

Cardinal Rubber & Seal Inc.
1545 Brownlee Avenue
Roanoke, VA 24014
Telephone (703) 982-0091

Chase-Walton Elastomers, Inc.
81 Apsley St.
P.O. Box A
Hudson, MA 01749
Telephone (617) 485-5600

Dunlop Limited GRG Division
Pimbo Industrial Estate
Skelmersdale, Lancashire WN8 9PW
England
Telephone 0695 2411

Shenandoah Industrial Rubber Co.
(B.F. Goodrich Dealer)
P.O. Box 640 J
802 Kesler Mill Road
Salern, VA 24153
Telephone (703) 387-0435

Flex Incorporated
7302 Industrial Park Blvd.
Cleveland, OH 44060
Telephone (216) 946-9424

Goodyear Rubber Products Corp.
331 McCarter Highway
Newark, NJ 07114
Telephone (201) 242-5550

Insulated Duct & Cable Co., Inc.
Armstrong Hose Division
88-T Stokes Ave.
Trenton, NJ 08605
Telephone (609) 883-3030

Jerry Bros. Belting Co., Inc.
1908 East Main Street
Richmond, VA 23223
Telephone (804) 643-6167

Kuriyama of America, Inc.
1221 Landmeier Road
Elk Grove Village, IL 60007
Telephone (312) 228-0300

L.T. Industries
711 W. 17th Street - Bldg 4
Costa Mesa, CA 92627
Telephone (714) 631-2741

Nat Aranson and Associates
7640 Gloria Ave.
Dept. J
Van Nuys, CA 91406
Telephone (213) 787-5160

River Rubber and Belting Co., Inc.
P.O. Drawer 23624
New Orleans, LA 70123
Telephone (504) 733-8843

Service Rubber & Gasket Co., Inc.
16341 Old Valley Blvd.
P.O. Box 348 T
La Puente, CA 91747
Telephone (213) 968-0743

Snap-Tite Hose, Inc.
Snap-Tite Bldg.
Union City, PA 16438
Telephone (814) 438-7616

Sun-Flow, Inc.
432 Pacific Coast Highway
Hermosa Beach, CA 90254
Telephone (213) 540-3390

Taylor-Parker Co., Inc.
1130 W. Kingwood Avenue
Norfolk, VA 23502
Telephone (804) 855-2041

Source: 1982 Thomas Register of American Manufacturers.

OTHER DATA — Consult also local telephone directories and industrial registers for local companies.

PRODUCT B.F. GOODRICH ACID AND CHEMICAL TANK TRUCK HOSE **No. 121**

APPLICABILITY

Gas	Liquid Sol	 Fl	 Sk	Solid Sol	 Fl	 Sk
	*	*	*			

DESCRIPTION – Hoses resistant to chemical attack.

OPERATING PRINCIPLE – Hollow tubing used in conjunction with pumps for the initial pickup or transfer of materials.

PHYSICAL SPECIFICATIONS –

LIQUID CONDUCTING HOSES

Commander (Acid Hose)	(Acid Hose)	Atlas (Chemical Hose)	Multi-Chem 100
Cover Material	Rubber	Rubber	Chemical resistant
Reinforcement	Several wrapped layers of cord fabric and wire reinforcement		Polyester yarn Braid and steel, Wire Helix
Inside Tube	Hypalon	Natural Rubber	Cross-linked polyethylene
Max. Temp.	Not Available		66°C for most chemicals
Sizes	12.5 to 200 mm I.D.	1.25 to 200 mm I.D.	25 to 77 mm I.D.

SOLIDS AND GAS CONDUCTING HOSES
Convertapipe (Solids)

	Wire Reinforced	Non-wire Reinforced	Type 105 (Solids)	Type 103 (Gases)
Cover Material	Smooth Black Rubber		Rubber impregnated fabric	
Reinforcement	Wrapped with up to 16 plies plus heavy coated steel wire	Wrapped with 2 or more plies natural rubber and armorite	2 to 4 plies wrapped construction with coil of round coated spring steel	
Inside Tube	Customer Specified		3.18 mm Armorite Rubber	1.19 mm Armorite Rubber
Sizes	250 to 500 mm I.D.		38 to 350 mm I.D.	

Industrial Hose (3600) - for: Anhydrous Ammonia

Cover Material	Black Rubber
Reinforcement	High tensile braided fibre plies; 38 mm (1.5 in) and 51 mm (2 in) sizes have additional braid of stainless steel
Inside Tube	High tensile rubber
Sizes	13 to 51 mm I.D. (0.5 to 2 in)

OPERATING SPECIFICATIONS –

Recommended uses for the described hoses are as follows:

Commander (suction or discharge):
Highly corrosive liquids, i.e. sulphuric, chromic and nitric acids.

Atlas (suction or discharge):
Inorganic acids except nitric, chromic, concentrated sulphuric and strong oxidizing agents. Withstands most inorganic salts and alkalis.

Multi-Chem 100:
Resists approximately 90% of all industrial chemicals except strong oxidizing acids such as nitric and chromic.

Convertapipe (wire-reinforced):
For conducting abrasive and corrosive materials such as ore, dry or suspended sand, gravel, grain, ground or powdered chemicals, metal shavings and sawdust.

Convertapipe (non-wire reinforced):
For carrying abrasive materials in suspension.

Type 105:
To conduct dust and abrasive materials in air.

Type 103:
For toxic and corrosive fumes.

3600 Anhydrous Ammonia:
For anhydrous ammonia or nitrogen fertilizer.

STATUS OF DEVELOPMENT AND USAGE – Commercially available products in wide use for transferring acids and chemicals.

PERFORMANCE – Documentation for application to spills of hazardous materials not obtained. Problems are not anticipated if hose is purchased from manufacturer fabricated to tolerate specific substances.

AVAILABILITY AND COMMERCIAL INFORMATION –

In Canada:

Epton Industries
521 King St. W.
Kitchener, Ontario
N2G 1C5
Telephone (519) 744-6530
Contact: Mr. Eric Post (extension 550)

Note that in 1983 B.F. Goodrich Engineered Products Division was sold to Epton Industries.

In the U.S.:

The B.F. Goodrich Company
Engineered Systems Division
Dept. 0709
500 S. Main St.
Akron, OH 44318
Telephone (216) 374-2000

OTHER DATA – A variety of other hoses is available for suction or discharge service for handling petroleum at ambient and low temperatures, and for water and steam transfer.

PRODUCT GATES CHEMICAL HANDLING HOSE **No. 122**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION — Various hoses constructed for chemical transfer.

OPERATING PRINCIPLE — Hollow tubing used for the initial pickup or transfer of materials.

PHYSICAL SPECIFICATIONS —

Acid-Chemical Transfer Hoses - 41HW, 42HW, 45HW

Materials (Tubes)	41HW: Hypalon
	42HW: Viton
	45HW: "Special Blend"

Length - Maximum 18.3 m (60 ft)
Available Sizes (I.D. mm) — 25, 32, 51, 64, 76, 102 (1, 1.3, 2, 2.5, 3, 4 in.)

Acid Discharge Hose - 1W

Length — Maximum 15.2 m (50 ft)
Available Sizes (I.D. mm) - 13, 19, 25, 32, 44, 51, 57, 60, 64, 76, 89, 102, 114, 127, 152, 168, 203, 254 (0.5, 0.7, 1, 1.3, 1.7, 2, 2.2, 2.4, 2.5, 3, 3.5, 4, 4.5, 5, 6, 6.6, 8, 8.6, 10 in.)

Hypalon Tube Acid Discharge Hose - 101W

Length: Maximum 15.2 m (50 ft)
Available Sizes (I.D. mm) — 13, 19, 25, 32, 44, 51, 57, 60, 64, 76, 89, 102, 114, 127, 152, 168, 203, 219, 254 (0.5, 0.7, 1, 1.3, 1.7, 2, 2.2, 2.4, 2.5, 3, 3.5, 4, 4.5, 5, 6, 6.6, 8, 8.6, 10 in.)

Acid Suction and Discharge Hose - 400SB

Length — Maximum 15.2 m (50 ft)
Available Sizes (I.D. mm) — 32, 38, 51, 57, 64, 76, 83, 89, 102, 127, 152, 168, 203, 254 (1.3, 1.5, 2, 2.2, 2.5, 3, 3.2, 3.5, 4, 5, 6, 6.6, 8, 10 in)

Hypalon Tube Acid Suction and Discharge Hose -401SB

Length - Maximum 15.2 m (50 ft)
Available Sizes (I.D. mm)- 25, 32, 38, 51, 57, 64, 76, 83, 89, 102, 127, 152, 168, 203, 219, 254 (1, 1.3, 1.5, 2, 2.2, 2.5, 3, 3.2, 3.5, 4, 5.6, 6, 6.6, 8, 8.6, 10 in)

Liquid Chemical Transfer - 49SB

Length - Maximum 15.2 m (50 ft)
Available Sizes (I.D. mm)- 19, 25, 32, 38, 51, 60, 64, 76, 89, 102, 114, 127, 140, 152, 168, 178, 203, 219 (0.7, 1, 1.3, 1.5, 2, 2.3, 2.5, 3, 3.5, 4, 4.5, 5, 5.5, 6, 6.6, 7, 8, 8.6 in)

Gates Special Thermoplastic Tube Stock-Neoprene Cover - 77B

Length - 15.2 to 30.5 m (50 to 100 ft) and over
Available Sizes (I.D. mm)- 6, 8, 10, 13, 19 (0.2, 0.3, 0.4, 0.5, 0.7 in)

Anhydrous Ammonia Hose - 73B-HB

Length - Reels up to 18.3 m (60 ft)
Available Sizes (I.D. mm)- 13, 19, 25, 32, 38, 51, 76 (0.5, 0.7, 1, 1.3, 1.5, 2, 3 in)

OPERATING SPECIFICATIONS –

Hose Model	Chemical Compatability and Working Pressures
41HW	Strong oxidizing solutions.
42HW	Highly aromatic fluids and chlorinated hydrocarbons. Working pressure 862 kPa.
45HW	Acids, chemicals, solvents. Working pressure 1034 kPa.
1W	Acids, salts, bases.
101W	Strong oxidizing solutions such as sulphuric acid at high temperatures.
400SB	Acids, salts and bases in maximum suction or discharge applications.
401SB	Strong oxidizing solutions, such as sulphuric acid at high temperatures in maximum suction or discharge.
49SB	Acids, chemicals, solvents.
77B	Solvents, lacquer thinners.
73B-HB	Liquid anhydrous ammonia. Working pressures up to 2134 kPa.

STATUS OF DEVELOPMENT AND USAGE – Commercially available products used for transferring acids and chemicals.

PERFORMANCE – Documentation for application to spills of hazardous materials not obtained. Problems are not anticipated if hose is purchased from manufacturer which has been fabricated to specific tolerances and requirements.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Gates Rubber Company
999 South Broadway
P.O. Box 5887
Denver, CO 80217
U.S.A.
Telephone (303) 744-1911

OTHER DATA – No other information obtained.

PRODUCT GOODALL CHEMICAL HOSE **No. 123**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – Transfer hoses designed for chemical service.

OPERATING PRINCIPLE – Hollow tubing used in conjunction with pumps for the initial pickup of materials or their subsequent transfer.

PHYSICAL SPECIFICATIONS –

Nuchem:	general service chemical hose available in suction/discharge or discharge only chlorinated polyethylene (CPE) cover available sizes: 25 mm (1 in) I.D. @ 1.2 kg/m up to 102 mm (4 in) I.D. @ 5.7 kg/m textile braided carcass with helix wire reinforcement and CPE tube
Newtype:	Hypalon tube black Neoprene cover textile braid carcass with helix wire reinforcement also available with rubber tube
Long Life:	acid chemical and solvent hose 5 mm rubber tube
Kem-Flex:	all purpose suction/discharge hose CPE synplastic tube with oil-resistant cover textile braided with helix wire available sizes: 19 mm (3/4 in) I.D. @ 1.1 kg/m up to 102 mm (4 in) I.D. @ 6.1 kg/m available in discharge only without helix wire reinforcement
Kem-Flex:	acid suction hose (or discharge) cross-linked polyethylene (PE) tube. neoprene cover textile braid construction with helix wire reinforcement
Kem-King:	chemical and solvent suction/discharge hose Viton tube Neoprene cover horizontal braided construction with helix wire reinforcement
Kemite:	rubber construction wall 5 mm thick textile braid carcass with helix wire reinforcement available sizes: 38 mm (1 1/2 in) I.D. @ 1.5 kg/m up to 102 mm (4 in) I.D. @ 5.5 kg/m lengths to 30.5 m
Goodite:	rubber construction consisting of wrapped duck carcass with flexible reinforcement of spiral wire lengths to 15.2 m available sizes: 127 mm (5 in) I.D. @ 121.6 kg/m up to 305 mm (12 in) I.D. @ 425.2 kg/m
Kem-Flex 200:	barge unloading hose cross-linked PE tube lengths to 30.5 m available sizes: 51 mm (2 in) I.D. @ 5.4 kg/m up to 152 mm (6 in) I.D. @ 15.9 kg/m

Kem-King 200:	Viton tube black Neoprene cover
Super-Lite 200:	nitrile tube and cover smooth bore textile braided, wire reinforced available sizes: 76 mm (3 in) I.D. @ 5.1 kg/m up to 152 mm (6 in) I.D. @ 15.8 kg/m maximum length 30.5 m also available as "Super-Lite 300" in same specifications only higher working pressure
Fluor-O-Prime T:	horizontally braided extruded smooth Teflon tube available sizes: 19 mm (3/4 in) I.D. @ 0.5 kg/m (15.2 m length) up to 32 mm (1 1/4 in) I.D. @ 1.6 kg/m (7.6 m length)
Fluor-O-Prime W:	wire braid reinforcement extruded smooth Teflon tube available sizes: 19 mm (3/4 in) I.D. @ 0.6 kg/m (15.2 m length) up to 32 mm (1 1/4 in) I.D. @ 1.6 kg/m (7.6 m length)
Teflon Convoluted Bore Hose:	available in wire braid and two braid textile construction helical convolutions 15.2 m lengths Neoprene cover
Super Long-Life:	stainless steel wire braid reinforcement tube constructed of butyl rubber Neoprene cover available lengths to 30.5 m available sizes: 19 mm (3/4 in) I.D. @ 0.6 kg/m up to 76 mm (3 in) I.D. @ 4.4 kg/m
Century 2000:	flexible mandrel construction nylon braid reinforcement black cover

OPERATING SPECIFICATIONS –

Nuchem:	resistant to the majority of common chemicals up to 66°c working pressure up to 689 kPa
Newtype:	for chemicals, acids and solvents
Long Life:	acids and other chemicals
Kem-Flex:	handles more than 500 common chemicals including esters and ketones up to 66°C working pressure up to 862 kPa
Kem-Flex:	acid suction hose general industrial service including esters and ketones
Kem-King:	chemical and solvent resistant
Kemite:	for corrosive, abrasive fluids and slurries high in acidic content working pressure up to 345 kPa
Goodite:	for large volumes of waste acids, abrasive slurry fly ash and other corrosive materials working pressure up to 689 kPa
Kem-Flex 200:	handles more than 500 common chemicals (up to 90% of all chemicals) including esters and ketones working pressure up to 1379 kPa

Kem-King 200:	working pressure up to 1379 kPa
Super-Lite 200/300:	"200": Working pressure up to 1379 kPa "300": Working pressure up to 2068 kPa suitable for sodium hydroxide
Fluor-O-Prime T Fluor-O-Prime W:	for corrosives, caking slurries and solvents working pressure up to 1724 kPa
Teflon Convoluted Bore Hose:	will handle all chemicals except molten alkali and fluor chemicals up to 121°C
Super Long-Life:	for anhydrous ammonia working pressure up to 2413 kPa
Century 2000:	for anhydrous ammonia

STATUS OF DEVELOPMENT AND USAGE – Commercially available products specifically designed for a wide range of chemicals. In use in the chemical process industries.

PERFORMANCE – No documentation received for application to spills of hazardous materials. No problems in this regard are anticipated due to the specific tolerances of the different hose types.

AVAILABILITY AND COMMERCIAL INFORMATION –

In Canada:

Goodall Rubber Company of Canada Ltd.
1160 Fewster Drive
Mississauga, Ontario
L4W 1A1
Telephone (416) 629-1624

In the U.S.

Goodall Rubber Co.
P.O. Box 8237
Trenton, NJ 08560
Telephone (609) 587-4000

OTHER DATA – Goodall is widely represented in Canada and the U.S. and has manufacturing facilities in both countries.

5 ULTIMATE DISPOSAL

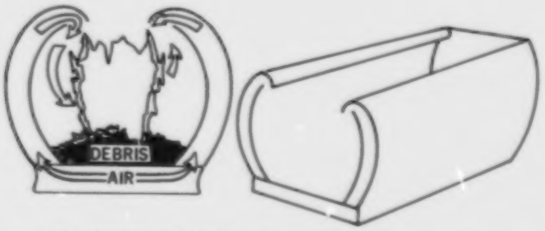
5 ULTIMATE DISPOSAL

5.1 Incineration/Combustion

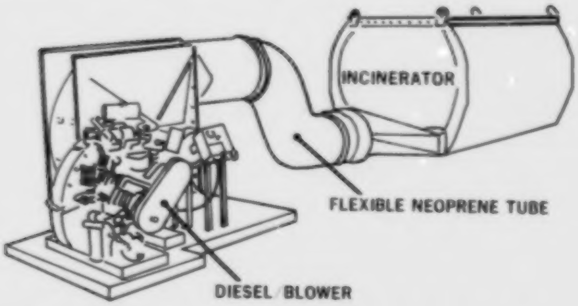
PRODUCT CLEANFIRE PORTABLE INCINERATOR **No. 124**

APPLICABILITY	Gas	Liquid			Solid		
		Sol	Fl	Sk	Sol	Fl	Sk
		*	*	*	*	*	*

DESCRIPTION – A heli-transportable incinerator consisting of a stainless steel chamber and a diesel-driven blower.



SCHEMATIC DIAGRAM OF INCINERATOR DESIGN



OPERATING PRINCIPLE – The blower circulates air between the double walls of the incineration chamber prior to its entry into the fire box to promote combustion. This feature eliminates the need for a refractory lining thereby reducing the weight of the unit to make it air-transportable and to facilitate assembly.

PHYSICAL SPECIFICATIONS –

Fire Box

Dimensions: 3 x 1.8 x 1.5 m (9 x 6 x 5 ft)
Material of Construction: No. 14 gauge 304 stainless steel outside skin
No. 10 gauge 304 stainless steel inner skin, end walls
Four lifting hooks, one in each corner.
Open top, hinged door at one end (for ash removal).
Weight 850 kg (1874 lb).

Diesel-driven Blower

Capacity: 198 m^3/min (6992 ft^3/min) (7000 cfm) air delivery.
Fuel Consumption: 8.0 L/h (2 U.S. gal/h) diesel at full throttle.
Weight 850 kg (1874 lb).

OPERATING SPECIFICATIONS –

Portability: helicopter-transportable in two loads each at 850 kg (1874 lb).
Assembly: no precise alignment required, approximately 10 minutes to set up once delivery of two components is made; requires wrench and screwdriver.
Smoke Generation: Ringleman No. 1 or No. 2.
Air Supply: generally 120% of complete combustion requirements.
Fire Box Temperature: approximately 1000° to 1100°C (1832° to 2012°F).
Rated Capacity: about 1 ton/h.

STATUS OF DEVELOPMENT AND USAGE – A full-scale prototype was successfully tested on February 2, 1983 with development and evaluation of the unit sponsored by the Canadian Offshore Oil Spill Research Association (COOSRA) and Environment Canada's Arctic Marine Oil Spill Program (AMOP). Commercial units have been subsequently sold to at least four different groups within Canada and the U.S. Usage is primarily intended for oil spill cleanup but, under some circumstances, may be appropriate for certain hazardous materials.

PERFORMANCE – Loading rates of 200 to 900 kg (440 to 1984 lb) of oiled debris have been achieved in test runs conducted in southern Ontario and in the Arctic (see references under Other Data). A peak operating temperature in the firebox has been measured at 1045°C (1913°F) with the outside wall reaching a temperature of 10°C (50°F) and end panels attaining 293°C (559°F) but generally fluctuating between 220° and 250°C (428° and 482°F). Smoke emission has been observed to range between Ringleman No. 1 and No. 2.

No evaluation data pertaining to the capability of the incinerator to combust hazardous materials are known to exist.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Energetex Engineering
498 Albert Street - Suite No. 7
Waterloo, Ontario
Canada
N2L 3V4
Telephone (519) 743-7191
Contact: Mr. Ed Twardus

OTHER DATA – For design criteria, general background information, and evaluation results refer to:

Potter, S.G. and Twardus, E.M., "Development and Testing of an Air-Transportable Incinerator", Proceedings of the Sixth Arctic Marine Oil Spill Program Technical Seminar, Edmonton, Alberta (June 14-16, 1983).

This entry is also based on correspondence dated November 23, 1983 from Mr. D. Smrke of Dome Petroleum Limited to Mr. M.F. Fingas, Environmental Protection Service, Environment Canada, Ottawa, Ontario, Canada.

PROTOTYPE DIESEL ENGINE INCINERATOR No. 125

APPLICABILITY	Gas	Liquid			Solid		
		Sol	Fl	Sk	Sol	Fl	Sk
			*	*			

DESCRIPTION – A prototype system designed to thermally destruct PCB-contaminated oil (Askarel). The system consists of a diesel engine, scrubber and an activated carbon filter.

OPERATING PRINCIPLE – Askarel is mixed with diesel fuel and fed into the diesel engine where it is burned. The exhaust is scrubbed with water, passed through an activated carbon filter and discharged to the atmosphere. The hydrogen chloride solution from the scrubber is neutralized with limestone.

PHYSICAL SPECIFICATIONS – 150 kW, six cylinder in-line Dorman diesel engine (200 hp).

OPERATING SPECIFICATIONS – Up to 75% Askarel fuel has been used, although most of the operating experience has been with a ratio of 50% Askarel and 50% diesel fuel by weight.

STATUS OF DEVELOPMENT AND USAGE – Prototype which has undergone limited testing.

PERFORMANCE – Destruction efficiencies are claimed to be greater than 99% for the whole system.
Tests indicate that 99.87% of chlorine fed to the unit is processed to chloride.
Incinerator is designed for liquid waste only.
Pilot system has been operated for 300 hours using askarel.

AVAILABILITY AND COMMERCIAL INFORMATION –

Distributor:

The D&D Group, Inc.
5 Race Street
St. Catherines, Ontario
L2R 3N1
Telephone (416) 688-1880
Contact: Mr. H. Sharp

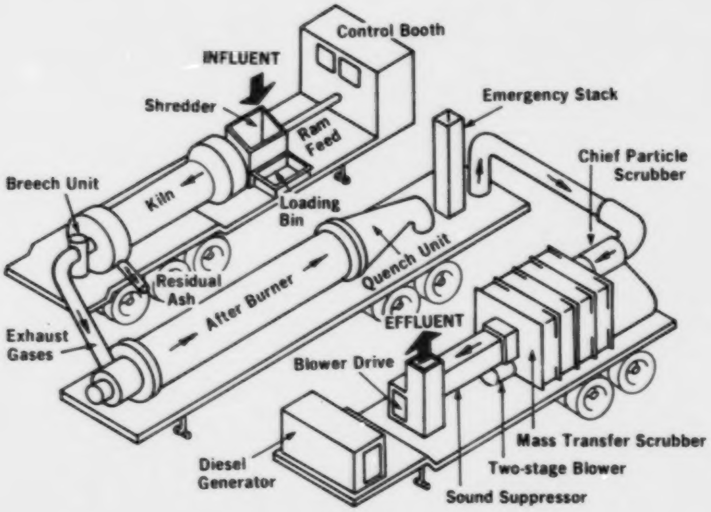
OTHER DATA – Dorman diesel may be available from Dorman Division of GEC in the U.K. Costs for the system capable of consuming up to 190 L/h of PCB liquid (1982 estimates):
Capital: Approximately $994 000
Operating: $1 512 000 not including cost of capital, depreciation, income and property taxes, and assuming the diesel is utilized 85% of the time.

Reference: Mr. G. Evans, personal communication, D & D Disposal Services (January 25, 1982).

PROTOTYPE EPA MOBILE INCINERATION SYSTEM No. 126

APPLICABILITY	Gas	Liquid			Solid		
		Sol	Fl	Sk	Sol	Fl	Sk
		*	*	*	*	*	*

DESCRIPTION – Prototype. A highway-transportable system (on three semi-trailers) designed to thermally destruct hazardous materials. The system consists of a shredder, kiln, secondary combustion chamber and flue gas scrubbers.



OPERATING PRINCIPLE – The hazardous material or debris is shredded (if necessary) then fed to the kiln (Trailer 1) where the material is incinerated at high temperatures. Residual ash is automatically removed at the discharge of the kiln and exhaust gases are passed to the afterburner (Trailer 2) where hazardous materials are destroyed. Exhaust from the afterburner is routed to the scrubbing system (Trailer 3). A particle scrubber removes fly ash and sub-micron phosphorus pentoxide. A mass transfer scrubber or adsorption tower removes sulphur dioxide and hydrochloric acid. The exhaust is then released to the atmosphere. Stack emissions are monitored.

PHYSICAL SPECIFICATIONS –

Loader - Ground level nestable loading hoppers. Mechanically/hydraulically lifted up to the edge of the shredder hopper for dumping.

Shredder - Shear type counter-rotating shaft unit with 25 mm (1 in) teeth. Automatic reverse for jam clearing (requires manual clearing when jammed item is of non-shreddable nature).

Ram Feeder - Hydraulically operated. Cylinder: 83 mm (3.3 in) dia. x 3 073 mm (121 in) stroke. Protected from shredder by a sliding steel cover plate. Ram trough separated from kiln by swing-up gates. Swing gate closest to kiln and trough in this area faced with Inconel 671 for corrosion and heat resistance.

Sludge and Liquid Feed - Port: 64 mm (2 to 5 in) (may be rod-cleared). Pumps available: Standard air-operated drum ram type for materials with contaminants up to the screen mesh of about 6 mm (0.2 in). Positive displacement piston pump (design incorporates a heated sludge tank and 25 mm (1 in) mesh screen).

Hydraulic Power Unit (Shredder) - 50 hp motor driven variable volume hydraulic pump. Horsepower compensated to eliminate excessive power demands.

Kiln - Direct fired. Sloped bottom. 1.3 m I.D. x 4.9 m (4.3 ft x 16 ft). Effective volume: 6.7 m^3 (236 ft^3). Lining of 152 mm (6 in) thick A.P. Green Kast-O-Lite 30 Refractory. Fired with two 102 mm (4 in) Maxom burners each capable of 12:1 turndown ratio.

Kiln Breeching and Duct to Afterburners - Constructed of Inconel 601. Duct has expansion joint for up to 305 mm (12 in) length adjustment in addition to a 20° misalignment.

Afterburner - Lined with Kasto-O-Lite 30. 1.3 x 11 m (I.D. x length) (4.3 x 36 ft).

Quenching - By wetted-throat venturi elbow using both fresh and recirculated water. Connected to ground-level water separator sump which includes an emergency stack and damper to protect the downstream scrubber system in the event of a quench water failure. Ducts and expansion joints from sump to Trailer 3 are constructed of Iconel 625.

Particle Scrubber - Cleanable High Efficiency Air Filter (CHEAF). Wetted glass fiber filter pad available in 30.5 m (100 ft) rolls. Filter pad automatically advanced as plugging starts.

Adsorber/Mass Transfer Scrubber - Coarse vane type fluid separator. 1.4 x 1.5 m (wide x high) (4.6 x 5 ft) high bed of 51 mm (2 in) Intalox plastic saddles 2.4 m (7.8 ft) in depth irrigated with 5% NaOH scrubbing fluid. Vessel structures constructed of fibreglass-reinforced plastic utilizing a bisphenol "A" base resin with alternate layers of woven roving and chopped strand fibreglass. Unit reinforced with steel angles. System complete with NaOH tanks and ground-level effluent storage tanks.

Blower and Drive - Single-stage blower speed modulated up to 3600 rpm. Driven by 125 hp diesel.

Sound Suppression and Stack - Sound suppression by commercial attenuators. 3.05 m (10 ft) tilt-up stack for gas exhaust dispersion.

Trailers - Three, each 13.7 m (45 ft) long. Kiln Trailer has three axles, the other two are tandem axle.

Additional Equipment - Diesel alternator set for all electrical requirements. Effluent tanks. Water and fuel tanks. Pumps. On-board hoist. Emergency. Other Operating Tools.

OPERATING SPECIFICATIONS –

Two second dwell in burners.
Temperature: 1121°C (2050°F).
Level of 3% oxygen or more is required for the system.
With bulk density or moist sand or no shearing, sub-system delivers up to 6.8 m^3/h (240 ft^3/hr) or about 10 834 kg/h (24 000 lb/hr).

System Capacities:

Waste Throughput: From 340 kg/h (750 lb/hr) @ 100% moisture content and 50% excess to 3288 kg/h (7248 lb/hr) @ 0% moisture content and 30% excess air. As a function of processed material and excess air: from 159 kg/h (350 lb/hr) processing water @ 70% excess air to 4082 kg/h (9000 lb/hr) processing dry sand @ 24% excess air.

STATUS OF DEVELOPMENT AND USAGE – Prototype device that has undergone comprehensive evaluation.

PERFORMANCE – A 15-hour test burn with fuel oil was completed in 1981 and modifications implemented as a result. This was followed by a series of five trial burn tests conducted in three phases from September 1982 through January 1983 at the EPA facility in Edison, NJ. The program verified that the mobile incineration system's performance complied with U.S. federal and state (New Jersey) regulations pertaining to the incineration of hazardous and toxic substances. The destruction of synthetic feed wastes was achieved at efficiencies in excess of 99.99% for feed rates of up to 32 kg/h of carbon tetrachloride, 43 kg/h of chlorinated benzene and 23 kg/h of PCB (Aroclor 1260). The air pollution control section of the mobile system removed in excess of 99% HCl and particulate matter to less than 180 mg/m^3 ("corrected").

AVAILABILITY AND COMMERCIAL INFORMATION – As of spring 1982, EPA had spent $2.2 million on the design, development, testing and permitting of the prototype mobile incinerator. Fabrication costs of a similar mobile incineration system, without development and testing expenditures, were estimated in April 1982 to be about $1.1 million.

For further details:

United States Environmental Protection Agency
Municipal Environmental Research Laboratory-Ci
Edison, NJ 08837
U.S.A.
Telephone (201) 321-6634
Contact: Dr. J.E. Brugger

OTHER DATA — Consult references cited. Also refer to U.S. Environmental Protection Agency Fact Sheet "EPA's Mobile Incineration System for Cleanup of Hazardous Substance Spills and Waste Sites", (April, 1982).

References: Tenzer, R., B. Ford, Jr., W. Mattox, and J.E. Brugger, (MB Associates), "Characteristics of the Mobile Field Use System for the Detoxification/Incineration of Residuals from Oil and Hazardous Material Spill Clean-up Operations", Journal of Hazardous Materials, 3 pp. 61-75 (1979) EPA Contract 68-03-2515.

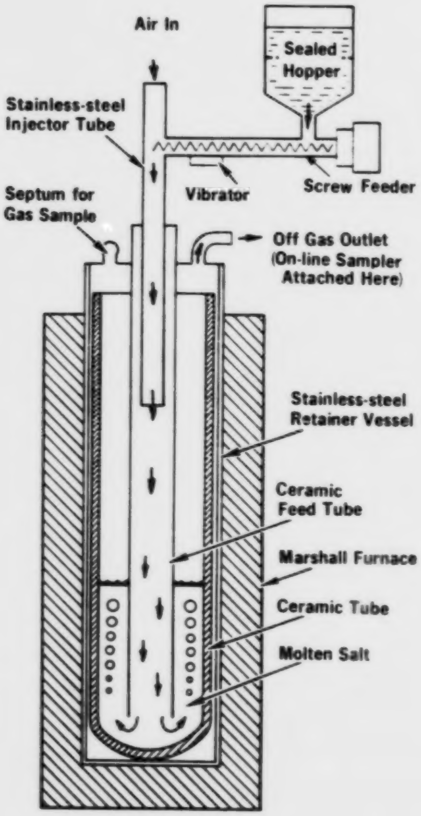
Yezzi Jr., J.J., J.E. Brugger, I. Wilder, F. Freestone, R.A. Miller, C. Hrommer, Jr., and R. Lovell, "The EPA-ORD Mobile Incineration System Trial Burn", 1984 Hazardous Materials Spills Conference Proceedings, Nashville, TN (April 9-12, 1984).

PROTOTYPE MOBILE MOLTEN SALT DESTRUCTION UNIT **No. 127**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*	*	*	*

DESCRIPTION – Prototype. Waste undergoes catalytic destruction as it contacts hot molten salt which is maintained at high temperature in a stainless steel vessel.



OPERATING PRINCIPLE – Waste and air are introduced beneath the surface of a sodium carbonate melt at 750 to 1000°C. Fuel is added if the waste is not sufficiently combustible. The salt melt provides the rapid transfer of heat and, in many cases, the catalytic breakdown of the waste to CO_2, H_2O, oxygenated salts, HCl, SO_2, etc., depending upon the materials involved. The sodium carbonate is compatible with gaseous reaction products and/or prevents their release and traps inorganic ash which must be removed. Otherwise complete conversion of the sodium carbonate would occur with an eventual loss of its fluidity and, ultimately, its acid removal capability. Salt makeup can, however, be added without interrupting system operation. Off gases are cleaned of particulates, primarily sodium chloride, by a Venturi scrubber or baghouse filter.

PHYSICAL SPECIFICATIONS – (pilot plant facility only)

Molten Salt Vessel	Overall Height: 5.2 m (17 ft) Outside Diameter: 1.2 m (4 ft) Material of Construction: 304 stainless steel Refractory Lining: 15.2 cm (6 in) blocks Amount of salt: 900 kg (1984 lb) to 1 m (3 ft) depth

OPERATING SPECIFICATIONS – (pilot plant facility)

Throughput ranges from about 23 to 113 kg/h.
Temperature generally ranges from 750 to 1000°C.
Destruction efficiency usually exceeds 99.99% (see Performance).
Elemental metals such as silver can be recovered from the melt.

STATUS OF DEVELOPMENT AND USAGE – Three molten salt facilities have been constructed including a bench-scale model, pilot-plant system, a larger unit (specifically for the gasification of coal). A fourth is available in a semi-mobile configuration for use in demonstrations and is capable of processing 45 kg/h (100 lb/h) of waste. As one of the last steps in the development stage, licencing arrangements for production units will have to be formalized.

The molten salt process has been conceived for the efficient disposal of hazardous material wastes.

Manufacture of a commercial mobile system, beyond the prototype stage, is possible but would have to be confirmed with Rockwell International.

PERFORMANCE – Typical data from destruction tests conducted by Rockwell on hazardous wastes are:

Type of Waste	Waste	Temperature (°C)	Concentration of Unreacted Waste in Off Gas (mg/m^3)	Concentration of Unreacted Waste in Melt (wppm)	Destruction Efficiency (%)
Chemical	PCB	750 to 900	0.5	0.08	>99.999
	Perchloroethylene Bottoms	850 to 950	ND* <0.5	NA**	
	Chloroform	818	ND <0.5	ND <0.1	>99.999
	Trichloroethane	840	ND <1.7	NA	>99.999
	Diphenylamine HCl	922	ND <0.4	ND <0.1	>99.999
	Nitroethane	892	ND <4.4	ND <1	>99.993
	Aqueous Slurry of TBP***	939	0.1	NA	>99.99
	Para-arsanilic acid	924	ND <0.8	ND <0.1	>99.999
Pesticides	DDT Powder	900	0.3	ND <0.5	99.998
	Malathion	900	0.06	ND <0.01	99.9998
Chemical Warfare Agents	VX	930	ND <0.00003	ND <3	>99.99999
	GB	925	ND <0.0003	ND <0.1	>99.999999
	Mustard	925	ND <0.03	ND <0.03	>99.99998

*ND - Not detected **NA - Not analyzed ***TBP - Tributylphosphate

AVAILABILITY AND COMMERCIAL INFORMATION –

Developer:

Rockwell International
Energy Systems Group
8900 De Soto Avenue
Canoga Park, CA 91304
U.S.A.
Telephone (818) 700-3977
Contact: Mr. A. Kohl

OTHER DATA – Information for this entry is based on personal communication with Mr. A. Kohl, Rockwell International, 12 June 1984 and the 1980 Rockwell International brochure Molten Salt Destruction (MSD) of Hazardous Wastes.

Additional data can be obtained from:

1) Kiang, Y-H. and A.A. Metry, Hazardous Waste Processing Technology, Ann Arbor Science Publishers Inc., U.S.A. (1982).

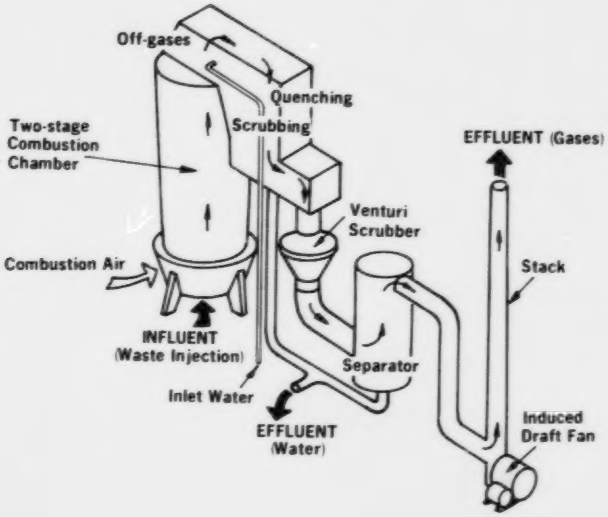
2) Yosim, S.J., K.M. Barclay, R.L. Gay, and L.F. Grantham, "Disposal of Hazardous Wastes by Molten Salt Combustion", Toxic and Hazardous Waste Disposal, (R.B. Pojasek, ed.) Ann Arbor Science Publishers Inc., U.S.A., Chap. 14 (1980).

PRODUCT PRENCO MOBILE INCINERATOR **No. 128**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*	*	*	*

DESCRIPTION – A mobile system for the thermal destruction of powders, liquids, sludges or slurries. It consists of a two-stage combustion chamber with associated holding tanks and gas scrubbing system. A rotary kiln may also be attached to the system for contaminated soil.



OPERATING PRINCIPLE – The materials to be incinerated are blended in holding tanks and injected into the combustion chamber. Off gases are scrubbed to remove particulates and acid mist in a high energy venturi scrubber and a wet, packed tower using caustic soda or lime slurry.

PHYSICAL SPECIFICATIONS – (568 L/h unit only). Complete unit is mounted on three flatbed trailers along with a mobile laboratory.

Incinerator -

Maximum rating: 6.2 x 10^6W (21 x 10^6 BTU/h)
Capacity: 0.16 L/s (150 U.S. gal/h) at 39 x 10^6 kJ/m^3 (140 000 BTU/gal)
Volume for Primary Chamber: 10 m^3 Volume for Secondary Chamber: 5.2 m^3
Construction of Chambers: Carbon steel with 200 mm refractory lining.
Type of Atomization: Air

Air Pollution Control System -

Components: venturi flooded elbow, packed tower separator exhaust system
Quench Section: number of sprays: 12 size of sprays: 11 mm @ 207 kPa
Materials of Construction: 316 Stainless Steel
Scrubbing Section(s): type Prenco 150/VVO construction material - carbon steel
Adsorber/Demister: construction material - ceramic saddles

Exhaust Draft Fan -

Capacity: 7100 L/s (saturated) (15 000 CFM)
Construction: carbon steel (coated)

Note that a second unit is available with a capacity of 1893 L/h (500 U.S. gph)

OPERATING SPECIFICATIONS – Suitable for broad range of unspecified chemicals including chlorinated hydrocarbons.

Incinerator –

Primary Chamber Retention Time: 1.186 s
Secondary Chamber Retention Time: 0.616 s
Maximum Temperature for refractory lining in chambers: 1649°C
Normal operating temperatures in chambers: 1260°C
Maximum operating temperatures in chambers: 1538°C
Feed pressure: 286 kPa (41.5 psi)
Atomization media/pressure 6.0 kPa to 9.5 kPa (0.875 to 1.375 psi)
Turn-down ratio: 5:1

Air Pollution Control System –

Maximum gas flow: 7080 L/s (15 000 ACFM)
Water: transition: 20 L/s @ 207 kPa
scrubber: 11.3 L/s (180 gpm)
blowdown: 757 L/day
make-up: 0.09 L/s (1.5 gpm)

Exhaust Draft Fan -

Static pressure: 207 kPa (30 psi)
Fan: 3600 rpm
Horsepower: 75 bhp

Utilities -

Electrical: 93 kW
Auxiliary fuel: cold start/warm up: 36 L/h (No. 2 Fuel Oil)
continuous: 180 L/h (No. 2 Fuel Oil)
Water: peak: 0.13 L/s (2 gpm)
average: 0.1 L/s (1.5 gpm)

STATUS OF DEVELOPMENT AND USAGE – Commercial product designed for the incineration of toxic and hazardous wastes at dump sites. Available on lease basis.

PERFORMANCE – In tests conducted at the McClellan Air Force Base in Sacramento, CA in 1978-9, PCB destruction was achieved at a rate determined to be 99.998%. The incinerator is suitable for the treatment of a range of chlorinated hydrocarbons.

Source: Personal Communication, Prenco Incorporated, 11 June 1984.

AVAILABILITY AND COMMERCIAL INFORMATION – Original model incinerator SE-3-150 and Air Pollution Control System 150/VVO available for lease also a second, larger capacity 1893 L/h (500 U.S. gal) system.

Manufacturer:

Prenco Incorporated
2601 West 14 Mile Rd.
Royal Oak, MI 48073
U.S.A.
Telephone (313) 399-6262
Contact: Mr. L. McNew, Marketing Director

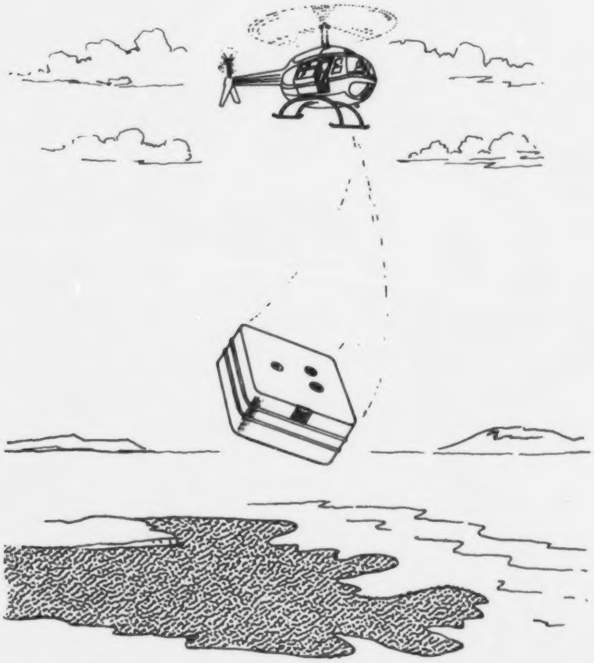
Approximate Lease Costs: $25 000 - $30 000 per month including system operation, depending on size of disposal problem and required length of time to process wastes.

OTHER DATA – Manufacturer should be consulted with regard to specific waste to be treated, services required (e.g., operation of incinerator, maintenance, chemicals stack testing, shipping, assembly, documentation, etc.) and costs.

PRODUCT PYROID PYROTECHNIC INCENDIARY DEVICE No. 129

APPLICABILITY	Gas	Liquid			Solid		
		Sol	Fl	Sk	Sol	Fl	Sk
			*				

DESCRIPTION – A light, compact device designed for the on-site combustion of floating oil or flammable hazardous chemical spills. The device consists of an incendiary device which is ignited by a delay primer.



OPERATING PRINCIPLE – The Pyroid device is activated by pulling out a firing clip. It is then dropped from a helicopter or fixed-wing aircraft onto the slick. The delay primer ignites the incendiary material approximately 25 seconds after the firing clip is removed to initiate self-sustained combustion of the flammable spill.

PHYSICAL SPECIFICATIONS –

Dimensions: 25 x 25 x 12.5 cm (10 x 10 x 5 in)
Weight: 2 kg (4.5 lb)
Uses a rocket-fuel-type incendiary solid material (40 to 70% ammonium perchlorate, 10 to 30% metal fuel, aluminum or magnesium, 14 to 22% binder).

OPERATING SPECIFICATIONS –

Heat Duration: 2 minutes
Flame Temperature: 1400 to 2300°C (2552 to 4172°F)
Shelf Life: 5 years
Designed to withstand dropping from a helicopter or fixed-wing aircraft at an altitude of 60 m (197 ft) with 100 km/h (62 mph) forward speed onto a frozen surface.
Has low 5 cm (2 in) draught.
Floats on slick surface.
Suitable for use in remote locations.
Will ignite confined spills.

STATUS OF DEVELOPMENT AND USAGE — Developed as a commercial product for oil removal on Arctic sea ice. Usage documented on crude oil slicks and not on spills of hazardous materials. Application could be considered for any flammable liquid, safety and other circumstances permitting.

PERFORMANCE — 10 preproduction devices were tested witn crude oil on the spring ice surface of Lac Laurier, Québec in 1981.

Preproduction proof tests - Lac Laurier,
CFB Valcartier - 12 April 1981

Test No.	Ignition Delay Time (s)	Burn Time (min: s)
1	misfire	–
2	15.7	2:20
3	22.7	4:15
4	misfire	–
5	22	2:24
6	16.8	3:21
7	20	2:26
8	20	2:21
9	19.3	2:28
10	17.9	2:11
Average	19.3	2:43

Note: Tests 1-8 deployed at 15 m (49 ft) altitude and 15 knots (7.7 m/s) airspeed. Tests 9 and 10 deployed at 30 m (98 ft) and 60 knots (31 m/s).

The impact roll (from the intended target) was markedly reduced by the square shape, compared to earlier circular prototypes.

AVAILABILITY AND COMMERCIAL INFORMATION —

Manufacturer:

Astro Pyrotechnics Ltd., P.O. Box 908
Guelph, Ontario
Canada N1H 6M6
Telephone (519) 822-2133
Contact: Mr. J.B. Edwards
Vice President and General Manager

Development sponsored by Environment Canada in cooperation with Defence Research Establishment, Valcartier (DREV).

OTHER DATA — The air-deployable igniter should be applicable to small, contained spills where in-situ combustion could be conducted in a controlled manner without threat to personal safety or the surrounding environment.

Dome Petroleum Ltd. through the Arctic Petroleum Operators Association (APOA) and Energetex Engineering of Waterloo, Ontario, Canada have developed a similar device for use on spilled crude oil surfacing on arctic sea ice in spring following a subsea blowout.

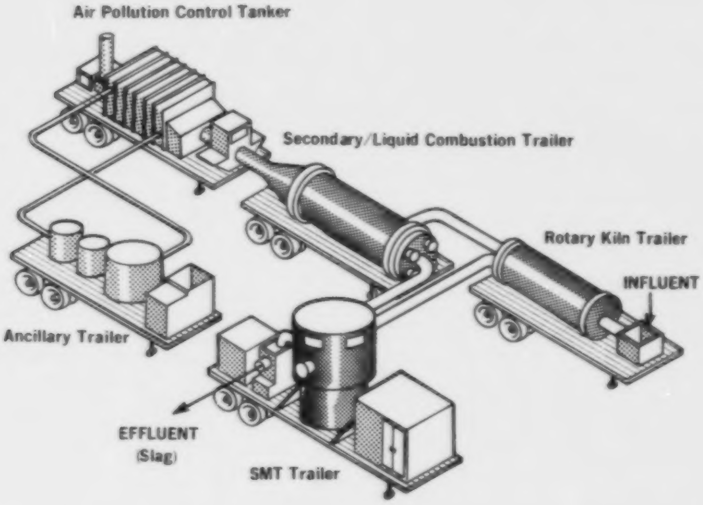
References: Pistruzak, W.M., "Dome Petroleum's Oil Spill Research and Development Program for the Arctic", Proceedings of the 1981 U.S. Oil Spill Conference, Atlanta, GA (March 2-5, 1981).

Couture, G. and P. Twardawa, Incendiary Devices for In-Situ Combustion of Crude Oil Slicks, Defence Research Establishment, CFB Valcartier, Québec, Canada, File 3621B-043 (January, 1983).

PRODUCT PYROMAGNETICS MOBILE INCINERATOR No. 130

APPLICABILITY	Gas	Liquid			Solid		
		Sol	Fl	Sk	Sol	Fl	Sk
		*	*	*	*	*	*

DESCRIPTION – A mobile system for the thermal destruction of solid and liquid hazardous materials. It consists of a rotary kiln, special melting treatment unit (SMTU) and high temperature oxidizer with associated equipment for pretreatment and residuals handling. The complete system is housed on five trailers.



OPERATING PRINCIPLE – The essential components of the system are the special melting treatment (SMTU) and the high temperature oxidizer. In the SMTU a mass of iron is melted by an induction heating coil. Contaminated solids which can be pretreated by shredding and/or drying in a rotary kiln, are added to the SMTU and undergo combustion at the surface of the molten iron. In the presence of a suitable flux, the wastes form a slag which is tapped off and quenched.

(When treating contaminated soil, the soil itself provides the necessary flux.) Heavy metals are claimed to be entrapped in the resulting "inert" silicate matrix.

Off gases from the rotary kiln and the SMTU, and contaminated liquids are fed to tne high temperature oxidizer, which consists of an oxygen burner followed by a burnout chamber. The use of oxygen reduces the volume of gas generated for scrubbing. The scrubbing system employed is a horizontally-mounted, water spray tower using limestone chips as the scrubbing agent. Residual contaminants and odours are removed in a charcoal filter before being vented to atmosphere. The complete system is operated under negative pressure by a diesel-powered induced-draft fan, to prevent escape of gases from the system.

PHYSICAL SPECIFICATIONS –

Complete unit is mounted on five 13.7 x 2.4 m (45 x 8 ft) trailers along with a mobile control van/laboratory:

1. Rotary Kiln Trailer

   Rotary Kiln with Refractory
   2 Burners (Air)
   Burner Control System

2. Secondary and Liquid Combustor Trailer

   Secondary Combustion Chamber
   2 Oxygen Burners
   2 Air Burners with Blower

2 Ash Breech Hopper
Shredder
Feed Hopper
Sludge Injector
Screw Feeder
Instrumentation
Blowers
Connecting Duct
Isolating Valves

Burner Management System
Quench Section
Emergency Stack Vent Assembly
Sump Assembly and Pump
Connecting Duct
Instrumentation
Isolation Valves

3. Air Pollution Control Trailer

Cheaf Particulate Scrubber
Mass Transfer Scrubber
Induced Draft Fan
Sound Suppressor
Stack Assembly
Bendix Monitoring System
O_2, CO, NO_x
Scrubber Recirculation Pump
Scrubber Control Valves
Mist Eliminator
Instrumentation
Diesel Generator 125 hp

4. Specialized Melting Treatment (SMT®) Trailer

SMT Pyrolysis Unit
Frequency Convertor
Bus Bar Assembly
Cooling Tower
Pumping Module
Refractory System
Hydraulic Unit
Instrumentation
Feed Conveyor
Charging Section
Quench Tank with Conveyor
Jib Crane
Ingot Casting System
Transformers
Connecting Duct System
Emergency Generator

5. Ancillary Trailer

Caustic Feed Vessel
Spent Caustic Vessel
Water Conditioning Unit
Brine Tank Pump
Caustic Feed Pump
Caustic Makeup Pump
Spent Caustic Pump
Cooling Tower
Cooling Water Pump
Liquid Storage Tank
Fuel Storage Tank
Liquid Feed Pump
Fuel Feed Pump
Makeup Water Pump
Storage Recirculation Pump
Fuel Recirculation Pump
Instrumentation
Valves

6. Mobile Control Van/Lab

GMC Motor Home or Equivalent
Control Room Video Display
Analog-Digital Control System
Line Printer
Console Panel
Laboratory Bench
Fume Hood
Analytical Misc. (Glassware, etc.)
Calorimeter
Atomic Absorption
Gas Chromatograph
Decontamination Safety Equipment
Air Pollution Monitoring Equipment

OPERATING SPECIFICATIONS –

Capacity:
SMT furnace: 2700 kg/h (6000 lb/h)
Oxidizing unit: 1500 L/h or 550 L/h (396 gal/hr or 145 gal/h) for PCB (50%)

Operating Temperature:
Rotary kiln: 980°C (1800°F)
SMT furnace: 1650°C (3000°F)
Oxidizing unit: 2200°C (4000°F)

Dwell Time in Oxidizing: 2 seconds

Oxygen Consumption (for PCB):
3 kg (7 lb) oxygen per kg (lb) of PCB in 50% admixture with kerosene

Refractory Life:
estimated 3 months at throughput of 4 t/h

Power Requirements:
1000 kW at 4160 V via 150 kVA transformer with backup from 75 kW diesel generator

Scrubber Volume:
9450 L (2500 gal) circulated at 12.5 to 19.2 L/s (3 to 5 gal/s)

Not suitable for mercury, radioactive materials and certain unspecified strong acids. Scrubbing system may require adjustment for other materials, e.g., those containing lead, arsenic etc.

STATUS OF DEVELOPMENT AND USAGE – Commercial product available for application to spills of hazardous materials. Has been used to incinerate asbestos, PCBs and hydrocarbons.

PERFORMANCE – Destruction efficiency of 99.999 943% was achieved in test burns of PCB waste conducted for the EPA in Tullahoma, TN in March, 1982.

Leaching column test performed, on Pyro-Magnetics ash residue, by the University of Massachusetts, indicated that "heavy metal contamination of ground water beneath the ash is unlikely".

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Pyro-Magnetics Corporation
20 Essex Street
P.O. Box 288
Whitman, MA 02382
U.S.A.
Telephone (617) 447-0448
Contact: Mr. D. Dyer
Product Engineering/Sales

Costs (July, 1981):

Capital: Approximately $3 million including laboratory and computerized control systems.
Operating: Approximately $250/t.

OTHER DATA – A similar high temperature melting process reduces asbestos waste to a related substance of pelletized glass-like granules which are inert and non-toxic.

A smaller 900 kg/h (2000 lb/h) unit, which is mounted on three trailers has also been under development.

A mobile laboratory accompanies the process.

References: Manufacturer's Literature; personal communication, Mr. D. Dyer, Pyro-Magnetics Corporation, (June 30, 1981).

M.M. Dillon Ltd., "Destruction Technologies for PCBs, Report EPS 3-EC-83-1, Environment Canada (February, 1983).

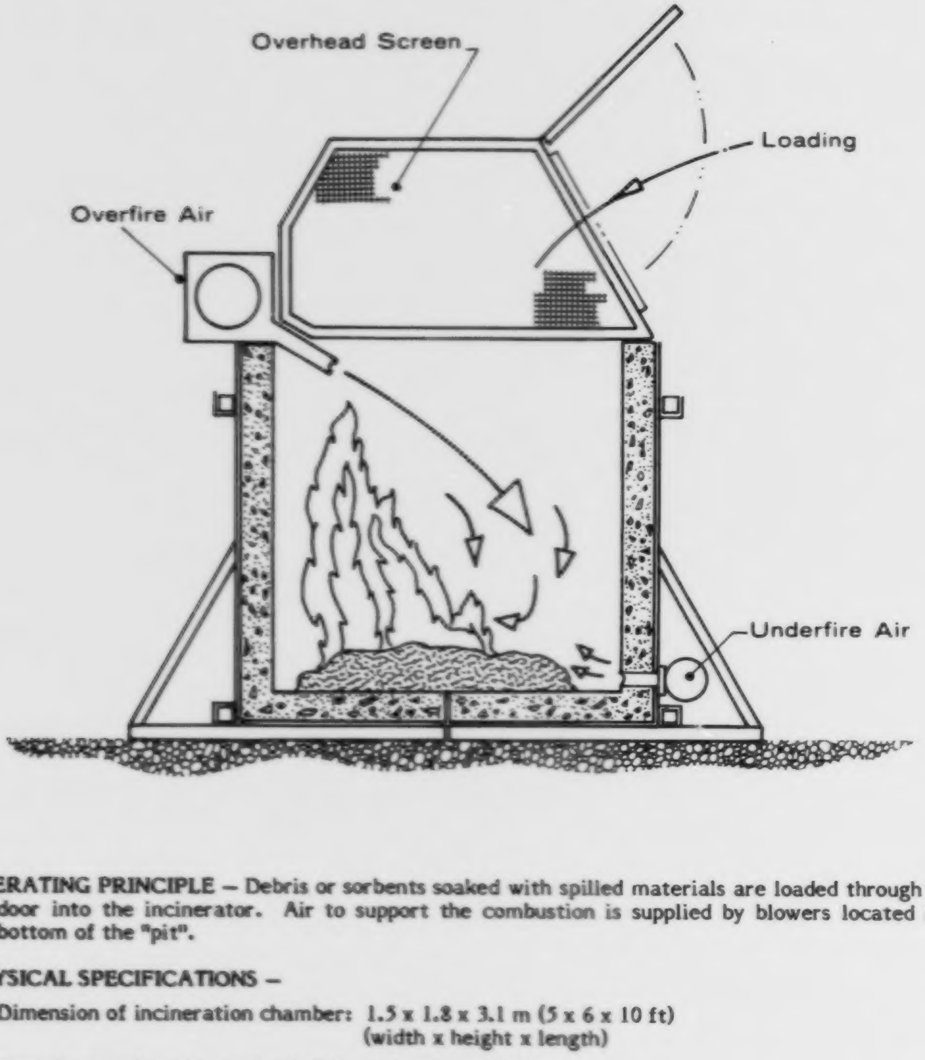
Hazardous Materials Intelligence Report (March 13, 1981).

PRODUCT TRECAN PORTABLE INCINERATOR **No. 131**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*	*	*	*

DESCRIPTION – The incinerator consists of a transportable "pit" with air-feed equipment.



OPERATING PRINCIPLE – Debris or sorbents soaked with spilled materials are loaded through a top-mounted door into the incinerator. Air to support the combustion is supplied by blowers located at the top and bottom of the "pit".

PHYSICAL SPECIFICATIONS –

Dimension of incineration chamber: 1.5 x 1.8 x 3.1 m (5 x 6 x 10 ft)
(width x height x length)

Overall ground space required: 2.4 x 5.5 m (8 x 18 ft)
Diesel engine: 20 hp, 2 cylinder air-cooled
Gross weight: 9100 kg (20 061 lb)
Maximum weight per section: 820 kg (1808 lb)
Combustion chamber constructed of ten sections
Hinged clean-out door located at one end of the incineration chamber
Each section is a steel frame with a cast refractory facing of 114 mm (5 in) thickness with a back-up of 51 mm (2 in) of insulating block.

OPERATING SPECIFICATIONS – Manufacturer claims that system is suitable for a wide variety of hazardous materials.

Capacity rated for domestic refuse and oil-soaked debris only:

907 kg/h (2000 lb/h) @ 1400 J/g for domestic refuse
454 kg/h (1000 lb/h) for oil-soaked debris

Diesel Fuel Consumption: 7.5 L/h (2 gal/hr)

Blower Rating: 161 m^3/min @ 2.5 kPa (5686 ft^3/min @ 0.416).

STATUS OF DEVELOPMENT AND USAGE – Commercial product developed on behalf of Environment Canada as part of the agency's Arctic Marine Oil Spill Program (AMOP). Usage has not been documented on hazardous materials.

PERFORMANCE – Tests conducted by Environment Canada on a test mixture of 75% by weight oil, 10% water, 4% straw, 7% wooden logs and 4% sorbents. It was burned at a rate of approximately 454 kg/h (1000 lb/h) with little or no visible smoke.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Trecan Limited
4540 Dixie Road
Mississauga, Ontario
Canada
L4W 1N2
Telephone (416) 625-4030
Contact: Mr. W.K. Lombard, President

OTHER DATA – The portable incinerator is based on a concept originally developed by Trecan to burn PCB liquids.

References: Manufacturer's Literature; Lombard, K.W., "Construction of an Air Portable Incinerator for Oil Spill Debris" Spill Technology Newsletter, pp. 288-292 (Sept.-Oct., 1979).

Personal communication, Mr. W.K. Lombard, Trecan Limited (May 4, 1981).

Ewing, H.B., Environment Canada: "Incinerator Development and Testing -Air Portable Open Pit Incinerator", Spill Technology Newsletter, p. 170 (May-June, 1979).

5.2 Fixation: Solidification/Encapsulation

PRODUCT FIXATION TECHNOLOGY - GENERAL LISTING **No. 132**

	Gas	Liquid			Solid		
APPLICABILITY		Sol	Fl	Sk	Sol	Fl	Sk
		*	*	*	*	*	*

DESCRIPTION — Waste fixation, encapsulation, and solidification/stabilization are synonymous terms used to describe processes of immobilizing, isolating or containing industrial waste materials.

These processes produce a solid material from a semi-solid (sludge) or liquid waste (primarily inorganic), and prevent it from reacting with or leaching into the surrounding environment (i.e., soil, water, groundwater).

The ideal fixation technique renders hazardous wastes nonreactive and immobile in a solid matrix of good dimensional stability, freeze-thaw resistance, low permeability, high stress tolerance, and resistance to attack by biological agents. This end product could be used for road or building construction or simply buried in an appropriate landfill.

OPERATING PRINCIPLE — The major categories of industrial waste fixation techniques are:

a) Cement-based techniques
b) Lime-based techniques
c) Thermoplastic techniques (including bitumen, paraffin and polyethylene)
d) Organic polymer techniques
e) Encapsulation techniques
f) Glassification
g) Self-cementing techniques

No one method is universally applicable, but each technique attempts to: 1) improve the handling and physical characteristics of hazardous wastes; 2) reduce leaching; and 3) reduce the solubility of specific groups.

Glassification and self-cementing are less popular techniques because of the complexity of the processes. The advantages and disadvantages of all seven techniques are summarized under PERFORMANCE.

Cement-based Techniques - These processes involve the reaction of water in the hazardous waste with anhydrous Portland (generally Type 1) cement. The hardening or curing mechanism involves the interlacing of thin, densely packed, silicate fibrils growing from the individual cement particles. The process continues for up to 28 days, but 50 to 90 % of the final compressive strength is attained within 7 days.

Lime-based Techniques - Aqueous solutions of hazardous materials are mixed with lime and fine-grained siliceous (pozzolanic) materials to form a pozzolanic concrete material. Natural pozzolans include volcanic ash and lava deposits. The most commonly used pozzolans include fly ash, ground blast furnace slag, cement-kiln dust, pulverized burnt fire brick and burnt shale. All classes of quicklime (CaO) and hydrated lime ($CA(OH)_2$), including waste lime, react well with pozzolans. Generally, finer pozzolan particles will produce stronger end products.

Thermoplastic Techniques - Hazardous waste sludges are dried, heated and dispersed through a matrix of bitumen, paraffin or polyethylene. The mixture solidifies during cooling and is usually containerized (e.g., steel drums) before burial. The waste is physically incorporated into the polymer and not chemically fixed.

Organic Polymer Techniques - A monomer is thoroughly mixed with wet or dry waste in a container (e.g., steel drum). An initiator is added to form a solid which does not chemically bond with the waste but instead entraps solid particles in a spongy mass. Any liquid associated with the waste is not retained and must be evaporated from the polymeric mass before final disposal. The most common polymer technique is the ureaformaldehyde process developed for nuclear waste processing. Polyvinyl and polyester have also been studied as possible polymer candidates.

Encapsulation Techniques: - Encapsulation is the process of enclosing hazardous wastes (wet or dry) in a coating or jacket of inert material (e.g., polyurethane, HPPE).

Glassification - Extremely hazardous materials may be mixed with silica and fused at high temperature to form glass.

Self-cementing Techniques - A small portion (8 to 10% by weight) of wastes containing large amounts of calcium sulphate or calcium sulphite, (e.g., flue gas cleaning or desulphurization sludges) are dewatered and calcined to produce partially dehydrated cementitious calcium sulphate or sulphite. This material is reintroduced to the balance of the waste, along with other additives, so that a hard, plaster-like solid is formed.

PHYSICAL SPECIFICATIONS — Fixation techniques are generally capital intensive processes based on mixers and reaction vessels which combine solidification agents with a waste stream. Many systems are commercially available.

The following process summaries are taken from reference 2, listed under OTHER DATA. Consult reference 1 and the contacts listed under AVAILABILITY AND COMMERCIAL INFORMATION for additional details regarding the processes.

Chemfix Process (Chemfix, Inc.) (Also see Entry No. 134.) A mobile treatment system has been developed which processes up to 380 000 L/10 h shift. Inorganic additives (cements and soluble silicates) are added to wastewaters, up to 10% by volume of the waste depending on the percent solids and nature of the wastes.

Dow Polymeric Solidification Process (Dow Chemical Co.) - This is an organic polymer (polyvinyl resins) based solidification process developed for low radioactive wastes from nuclear power plants. Consult Dow and reference 1 for more information.

Calcilox (Dravo Lime Co.) - A cement-based fixation additive: dry, free flowing, light grey coloured powder of inorganic origin. It is hydraulically active and improves the handling and ultimate disposal characteristics of the slurries with which it is mixed.

ETC Solidification System (Environmental Technology Corp.) - (Also see Entry No. 133 - Bentonite/-Cement Fixation Process.) A combination of reagents is used to encapsulate the moisture and chemically bond heavy metals and other chemicals of a sludge into a soil-like material. Lime is used to neutralize acidity and complex heavy metal cations as insoluble hydroxides. Another reagent acts as an ion exchange medium, completely removing heavy metals and excess water. Additional reagent bridges sludge particles to increase physical strength and load-bearing capacity of the final sludge.

Poz-O-Tech Process (I.U. Conversion Systems, Inc.) - The Poz-O-Tec encapsulation mechanism occurs along two reaction paths: 1) silica and lime from fly ash and lime-bearing additives undergo pozzolanic reactions to yield calcium silicates, calcium aluminates, and calcium sulphoaluminates; and 2) soluble solids from fly ash react quickly with lime and alumina from fly ash glass, yielding primarily a cementitious gel matrix.

Silicate Solidification Process (Ontario Liquid Waste Disposal Ltd.) - This solidification process is covered under Canadian Patent No. 1024277 (issued 10th January, 1978). It is based upon the production of stable silicate compounds, similar to geological materials which result when alkaline and silicate reagents are added to liquid wastes.

Polyester Encapsulation (Washington State University) - Stable water-in-polyester emulsions are produced by dispersing aqueous wastes into unsaturated liquid polyester resins at high shear rates. The aqueous droplets are individually encapsulated by thin polyester shells which agglomerate into a hard water-retaining solid resembling fine-grained plaster. Washington State University has developed a pilot-scale encapsulation process using polyester resins as the encapsulant. (WSU provides expertise in this field and has not commercialized the process as of yet.)

Petrifix Process (Pec Engineering) - Toxic sludge is treated with a mixture of calcium silicates and an activator so that hydrated silicates and silico-aluminates of a particular composition and structure can be obtained. Solidification is not immediate, as is the case of most pozzalonic reactions, but the strength of the Roman-type concrete increases with curing.

Terra-Crete Process (Sludge Fixation Technology, Inc.) - The Terra-Crete process is a self-cementing process based on the production of a cementitious material from calcium sulphite hemi-hydrate or calcium sulphate. A portion of the sulphite/sulphate sludge stream is dried and calcined to produce a cementitious agent. This material and other additives (as needed) are introduced into the waste stream and react to form a hard, low permeability mass from the sludge.

Terra-Tite Process (Stabatrol Corporation) - The Terra-Tite process involves the addition of cementitious materials to the waste sludge to produce a concrete-like material.

Sealosafe (Stablex Corporation) - The Sealosafe process involves adding two silicate-based powders to be dissolved or dispersed in water, thereby producing a slurry. The slurry sets into a rigid, rock-like cast. This mass is referred to as synthetic rock due to its physical and chemical form.

The physical and chemical interactions which take place simultaneously are referred to as the mechanism of crystal capture. Up to ten additional ingredients are also used, depending upon the type of waste to be treated, to enable the crystal capture mechanism to operate under optimum conditions.

Takenaka Sludge Treatment (TST) System (TJK, Inc.) - The TST system is a technique for solidifying mud of comparatively high water content or sludge discharge from factories and plants. It transforms the material into a form easy to handle for utilization in land reclamation and pollution control. Treatable material can be widely dispersed, settled sludge, or sludge obtained directly from the factory or plant. In the case of sludges with toxic substances such as mercury, chromium and cadmium, TST treatment stabilizes and chemically fixes these harmful substances.

Special additives are used for stabilizing harmful substances. Several series of hardeners are used depending upon the specific mud or sludge to be treated.

TRW Polymeric Encapsulation Techniques (TRW Systems Group) - TRW Company has done extensive testing, development and evaluation on fixation technology for the EPA. Refer to Entry No. 7, Polymeric Encapsulation of Containerized Hazardous Materials, and reference 1 for more detailed discussion.

Volume Reduction and Solidification System (Werner and Pfleiderer Corp.) Refer to Entry No. 137.

OPERATING SPECIFICATIONS – The following information is taken from reference 2.

Chemfix Process (Chemfix, Inc.) (Also see Entry No. 134.)

A cement-based solidification process, Chemfix reacts with polyvalent metal ions to yield a stable, insoluble, inorganic matrix structure which entraps other nonreactive materials. Certain organics, toxic anions and nontoxic (but undesirable constituents) cannot be treated by the Chemfix method.

Dow Polymeric Solidification Process (Dow Chemical Co.)

Consult Dow and reference 1.

Calcilox (Dravo Lime Co.)

Calcilox is typically applied to coal dust, uranium mill tailings, and the sludge of sulphur compound scrubbers operating on the flue gas of coal-fired utility plants. Sludges containing sewage and organic wastes cannot be treated using this technique.

ETC Solidification System (Environmental Technology Corp.)

Sulphuric acid, hydrochloric acids and other pickling acids, spent plating solutions, scrubber and organic sludges and industrial waste treatment sludges are the hazardous wastes commonly solidified by the ETC process. (No wastes were listed as incompatible with the ETC process.)

Poz-O-Tec Process (I.U. Conversion Systems, Inc.)

This lime-based, pozzalonic solidification system was initially developed for treating SO_2 sludges from scrubbers in the electric utility industry. It has also stabilized electroplating, steel mill, and chemical process wastes. Some organic wastes (not specified) are not suitably treated by the Poz-O-Tec process. The pozzolanic reactions may occur over a period of months, but no special temperature control or other equipment is required.

Silicate Solidification Process (Ontario Liquid Waste Disposal Ltd.)

This process stabilizes and solidifies most inorganic chemicals and wastes containing acids, chromium, copper, iron, magnesium, manganese, nickel, zinc, cadmium, lead, mercury, vanadium, chlorides, sulphates and phosphorus. Tests have shown that some organic wastes of up to 20% by volume of formulated inorganic wastes have been treated successfully on a case-by-case basis. A plant completed in March 1977, solidifies over 1590 m^3 (350 000 Imp. gal) of industrial liquid wastes per month, yielding a soil-like product which was used to cover a sanitary landfill site in Hamilton, Ontario (Ref. 1, p. 350).

Polyester Encapsulation (Washington State University)

The process is effective in encapsulating low-level radioactive wastes, metal ion wastes, cyanides and arsenic wastes, and some specific organics such as kepone, PCB, and some pharmaceutical wastes. The process is not effective on very highly acidic sludges (especially below pH 1.0).

Petrifix Process (Pec Engineering)

The Petrifix process is used in France and the U.K. Common, relatively inexpensive chemicals are used and require no sophisticated handling or storage.

Types of Wastes Which Can be Treated by the Petrifix Process (Ref 1, p. 152)

Origin	Type of Waste	Main Pollutants
Electroplating and Metal Finishing	Schlams	Chromates, cyanides, heavy metals, acids (Cr' Zn, Hg. . .)
Chemical Industry	By-products of effluent treatment	Heavy metals, organometallics, low polymers
Mechanical	Effluent treatment plant	Dusts, oils
Electronics and Electric Industry	Tank bottoms, effluent treatment sludges	Cyanides, copper, zinc, nickel,
Oil and Petro-chemical Industry	Digested sludge catalyst, A.P.I. separator sludge	Heavy metals, dusts
Municipal Treatment Plant	Digested sludge	Organics, heavy metals
Agrobusiness	Sewage sludges organic sludges	Proteins, lipids, glucides, organometallics

Terra-Crete Process (Sludge Fixation Technology, Inc.)

The system is primarily designed to operate with sulphite/sulphate-based sludges produced from SO_2 stack scrubbing operations but is adaptable to other situations where calcium sulphite/sulphate sludges can be obtained. Wastes untreatable by the Terra-Crete process were not specified.

Terra-Tite Process (Stabatrol Corporation)

Most industrial wastes can be treated. The Terra-Tite process has great technical flexibility. Wastes which cannot be treated by the Terra-Tite Process were not specified.

Sealosafe (Stablex Corporation)

The process is suitable for:

1) All inorganic wastes. The process is exceptionally successful in treating all heavy metals, arsenic, mercury and asbestos. The process also deals with anionic wastes such as fluoride, chloride, etc.

2) Organic wastes which can be homogenously incorporated into an aqueous phase either by dissolution, suspension or absorption.

3) Wastes in (1) or (2) above in liquid, solid, or sludge form, including contaminated articles such as filter cartridges, clothing, rubber boots, etc.

The process is not suitable for solidification of:

1) Oils, solvents and greases which are not miscible with an aqueous phase.

2) Very large quantities of water with minimal amounts of toxic ingredients.

Takenaka Sludge Treatment (TST) System (TJK, Inc.)

Two types of sludges tested and found unsuitable for the TST system were sludge produced from a wool scouring plant (greater than 20% fats and oils) and sludges containing large amounts of paint wastes.

TRW Polymeric Encapsulation Techniques (TRW System Group)

See under PHYSICAL SPECIFICATIONS.

Volume Reduction and Solidification System (Werner and Pfleiderer Corp.)

Refer to Entry No. 137.

STATUS OF DEVELOPMENT AND USAGE – With the exception of the fixation technology developed by TRW Systems and Washington State University, all of the processes described in this entry are used commercially. (The above two systems have been studied and developed to laboratory scale only.) The Chemfix process was the only mobile system identified in the references cited; however, the cement- and lime-based processes could be mobilized in a unit such as the EPS Mobile Processing and Transfer Unit, Entry No. 135.

PERFORMANCE – The following data pertain to the general categories of fixation methods. Refer to reference 1 and the contacts listed for more specific performance information.

COMPARISON OF FIXATION TECHNIQUES

Process	Advantages	Disadvantages
Cement-based	1. Additives are available at a reasonable price.	1. Large amounts of cement are required, making the weight and volume of the final product about double that of other solidification processes.
	2. Cement mixing and handling techniques are well developed.	
	3. Processing equipment is readily available.	2. The alkalinity of cement drives off ammonium ion as ammonia gas.
	4. Extensive drying or dewatering of waste is not required because cement can be added to adapt to a wide range of water contents.	3. Low-strength cement-waste mixtures are often vulnerable to acidic leaching solutions. Extreme conditions can result in decomposition of the fixed material and accelerated leaching of the contaminants.
	5. Processing is reasonably tolerant of chemical variations in sludges.	
	6. The strength and permeability of the end-product can be varied by controlling the amount of cement added.	4. Pretreatment, more-expensive cement types, or costly additives may be necessary for stabilization of wastes containing impurities that affect the setting and curing of cement.
	7. Leaching characteristics can be improved by sealants.	

COMPARISON OF FIXATION TECHNIQUES (Cont'd)

Process	Advantages	Disadvantages
Lime-based	1. The additives are generally very inexpensive and widely available. 2. Equipment required for processing is simple to operate and widely available. 3. Chemistry of pozzolanic reactions is well known. 4. Extensive dewatering is not required as water is required in the curing process.	1. Lime and other additives add to weight and bulk of waste. 2. Stabilized sludges are vulnerable to acidic solutions. 3. Setting times are slower than for cement. 4. The end product may require compaction during placement.
Thermoplastic	1. Leachate rates are notably lower than cement-based fixation techniques. 2. Drying the waste reduces the overall volume to be treated. 3. End-product is fairly resistant to most aqueous solutions. 4. Thermoplastic materials adhere well to incorporated materials. 5. Materials embedded in a thermoplastic matrix can be reclaimed if needed.	1. Wet sludges must be pre-dried. 2. Expensive equipment and skilled labour are generally required. 3. Cannot be used with wastes which decompose at high temperatures, especially nitrates and certain plastics. 4. Fire hazard, especially with bitumen and strong oxidizers. 5. Some objectionable oils and odours may be released during heating. 6. Salts allowed to rehydrate in the thermoplastic matrix will expand and fracture the matrix. 7. The plasticity of the matrix may require a secondary container for transport and disposal of the material.
Organic Polymer	1. Only small quantities of additives are usually required to cause the mixture to set. 2. Organic resins are less dense than cement. 3. Air curing polymers require no high temperatures for curing.	1. The final solidified polymer must be dried before ultimate disposal. 2. Uncombined or "weep" water must be allowed to evaporate to produce a fully cured polymer. The weep water may be strongly acidic and may contain high levels of pollutants.

COMPARISON OF FIXATION TECHNIQUES (Cont'd)

Process	Advantages	Disadvantages
Organic Polymer (Cont'd)		3. Some initiators are corrosive and require special handling equipment.
		4. Fumes released during polymerization may be harmful or disagreeable.
		5. Some polymers are biodegradable.
Encapsulation	1. Very soluble contaminants are totally isolated from the environment.	1. Resins are expensive.
	2. Usually no secondary container is required, because the coating materials are strong and chemically inert.	2. Process requires large amounts of energy for drying, fusing and forming the jacket.
		3. The sludge has to be dried before the process can be applied.
		4. Certain jacket materials are flammable.
		5. Skilled labour is required to operate molding and fusing equipment.
Glassification	1. The process is assumed to produce a high degree of containment of wastes.	1. The process is energy-intensive. A charge must be heated to 1350°C to produce a satisfactory melt.
	2. The additives used are relatively inexpensive (syenite and lime).	2. Some constituents, especially metals, may be vaporized before they combine with the molten silica in the glass.
		3. Specialized equipment and trained personnel are required for this type of operation.
Self-cementing	1. No major additives have to be manufactured and shipped to the processing site.	1. Only high sulphate or high sulphite sludges can be used.
	2. The process is reported to produce faster setting times and more rapid curing than comparable lime-based systems.	2. Self-cemented sludges have much the same leaching characteristics as cement and lime-based systems.
	3. The material produced is stable, nonflammable and nonbiodegradable.	3. Additional energy is required to produce the calcined cementitious material.

COMPARISON OF FIXATION TECHNIQUES (Cont'd)

Process	Advantages	Disadvantages
Self-cementing (Cont'd)	4. There are reports of effective heavy metal retention perhaps related to chemical bonding of potential pollutants (12).	4. The process requires skilled labour and expensive machinery in calcining waste and mixing the calcined waste with additives to produce the fixed waste.
	5. These systems do not require completely dry waste. The hydration reaction uses up water.	

Based on references 2 and 3 (See OTHER DATA)

AVAILABILITY AND COMMERCIAL INFORMATION –

Chemfix, Inc.
1675 Airlane Highway
Kenner, LA 70063
U.S.A.
Telephone (504) 729-4561
Contact: Mr. Bentley B. MacKay,
President

Dow Chemical Co.
2020 Dow Center
Midland, MI 48640
U.S.A.
Telephone (517) 636-1000
Contact: Mr. Harold E. Filter

Dravo Lime Co.
650 Smithfield St.
Pittsburgh, PA 15222
U.S.A.
Telephone (412) 566-4444
Contact: Mr. C.J. McCormick

Environmental Technology Corp.
Suite 200
1517 Woodruff Street
Pittsburgh, PA 15220
U.S.A.
Telephone (412) 431-8586
Contact: Mr. Albert R. Kupiec, V.P.

I.U. Conversion Systems, Inc.
115 Gibralton Road
Horsham, PA 19044
U.S.A.
Telephone (215) 441-5920
Contact: Mr. Richard W. Patlon,
Industrial Sales Manager

TJK Inc.
7407 Fulton Avenue
North Hollywood, CA 91605
U.S.A.
Telephone (213) 875-0410
Contact: Masaaki Endo, General Manager

Ontario Liquid Waste Disposal, Ltd.
or Canadian Waste Technology, Inc.
160 Torbay Road
Markham, Ontario
Canada
L3R 1G6
Telephone (416) 495-9502
Contact: David Krofchak, Canadian
Waste Technology

Pec Engineering
Paris, France

Sludge Fixation Technology, Inc.
227 Thorn Avenue
P.O. Box 32
Orchard Park, NY 14127
U.S.A.
Telephone (716) 662-1005
Contact: Mr. Richard E. Valiga

Stabatrol Corporation
1402 Conshohocken Road
Norristown, PA 19401
U.S.A.
Telephone (215) 279-3992

Stablex Corporation
Suite 112
2 Radnor Corporation Center
Radnor, PA 19087
U.S.A.
Telephone (215) 688-3131
Contact: Mr. John Scofield

Washington State University
Dept. of Material Science and Engineering
Polymeric Materials Section
Pullman, WA 99164
U.S.A.
Telephone (509) 335-6784
Contact: R.V. Subramanian

Note: This company has contracted to market the Takenaka Sludge Treatment (TST) System (Takenaka Komuten Co., Osaka, Japan) in the U.S.

TRW Systems Group
One Space Park
Redondo Beach, CA 90278
U.S.A.
Telephone (213) 535-4321
Contact: H.R. Lubowitz, Staff Scientist

Werner & Pfleiderer Corp.
663 East Crescent Avenue
Ramsey, NJ 07446
U.S.A.
Telephone (201) 327-6300
Contact: Mr. R.D. Doyle
(See Entry No. 137)

Other commercially available solidification processes identified but not discussed in the references cited include:

Solidification Systems/Agents (Ref 1, p 6 & 36)

Vendor or Developer (U.S.A.)	Type
Aerojet Energy Conversion Co. Sacramento, CA Bitumen	Cement Urea-formaldehyde
ANEFCO, Inc. White Plains, NY	Urea-formaldehyde
ATCOR, Inc. Peekskill, NY	Cement
Brookhaven National Laboratory[a] Upton, Long Island, NY	Cement with organic polymers
Chem-Nuclear System, Inc. Bellevue, WA	Cement Urea-formaldehyde
Chicago Fly Ash (American Admixtures) Chicago, IL	N/A
Consolidated Technology Inc. Bellevue, WA	N/A
Delaware Custom Materials Cleveland, OH	Cement with shale or silicates
Dow Chemical Company Midland, MI	Organic polymer
Energy, Inc. Idaho Falls, ID	Cement Urea-formaldehyde
Estacron International, Inc. Winter Haven, FL	N/A
Fujibeton Associates Washington, DC	N/A
General Electric Company San Jose, CA	Cement
Hittman Nuclear & Development Corp. Columbia, MD	Cement Urea-formaldehyde
John Sexton Contractors Oakbrook, IL	N/A

Solidification Systems/Agents (Cont'd)

Vendor or Developer (U.S.A.)	Type
Lancy Laboratories Zelienople, PA	N/A
Newport News Industrial Corp. Newport News, VA	Bitumen
Nuclear Sources and Services Inc.	N/A
Oak Ridge National Laboratory[a] Oak Ridge, TN	Cement with additives
Protective Packaging, Inc. Jeffersontown, KY	Urea-formaldehyde
Soilonazone Chicago, IL	N/A
South Research Institute San Antonio, TX	N/A
Stock Equipment Company Cleveland, OH	Cement Urea-formaldehyde
Todd Research and Technical Div. Galveston, TX	Cement
United Nuclear Industries Richland, WA	Cement with sodium silicate Urea-formaldehyde
United Technologies Sunnyvale, CA	Organic polymer
Wehran Engineering Corp. Middletown, NY	
Westinghouse Electric Corp. Pittsburg, PA	Cement with vermiculite

[a]Noncommercial applications; N/A = Not Available

OTHER DATA

Commercial Fixation Processes Described in Volume 1

Process	Vendor
Volume Reduction and Solidification System (See Entry No. 137)	Werner & Pfleiderer Corp.
Poz-O-Tec	I.U. Conversion Systems, Inc.
Terra-Tite Process	Stabatrol Corporation
Terra-Crete	Sludge Fixation Technology, Inc.
Encapsulation Studies for U.S. EPA	TRW Systems Group

Commercial Fixation Processes Described in Volume I (Cont'd)

Process	Vendor
Polyester Encapsulation	Washington State University
Chemfix Process (See Entry No. 134)	Chemfix, Inc.
Calcilox	Dravo Lime Co.
Petrifix	Pec Engineering
Polyvinyl Encapsulation	Dow Chemical
Sealosafe	Stablex Corporation
Silicate Process (Canadian Patent No. 1024277)	Ontario Liquid Waste Disposal Ltd. (Canadian Waste Technology, Inc.)

References:

Toxic and Hazardous Waste Disposal Volume I: Processes for Stabilization/Solidification, (Rober B. Pojasek, ed.) Ann Arbor Science Publishers, Inc., Ann Arbor, Michigan (1979).

Protective Barriers for Containment of Toxic Materials, (R. Fung, ed.) Noyes Data Corporation, Park Ridge, New Jersey, pp. 269-288 (1980).

Robert B. Pojasek, "Solid-waste disposal: Solidification", Chemical Engineering (August 13, 1979).

CONCEPT BENTONITE/CEMENT FIXATION PROCESS No. 133

APPLICABILITY	Gas	Liquid			Solid		
		Sol	Fl	Sk	Sol	Fl	Sk
		*			*		

DESCRIPTION – A method for converting liquid and slurry hazardous wastes into inert, non-polluting solid substances by absorption, with minimal leaching of the absorbed waste to the environment. The wastes are absorbed into and contained by a bentonite/Portland cement mixture.

OPERATING PRINCIPLE – The bentonite clay acts as a basic ion exchange medium in aqueous solution which readily absorbs metal ions and enters into base exchange with basic organics extracting them from the solution. The Portland cement in the mixture undergoes several reactions with water when setting to give a physical stabilitity to the bentonite clay/Portland cement/industrial waste mixture.

PHYSICAL SPECIFICATIONS – Not available.

OPERATING SPECIFICATIONS –

Reaction conditions:

0.25 to 30% of the weight of the waste of bentonite clay.
0.25 to 50% of the weight of the waste of Portland cement.
pH of the waste: 6 to 11.
a reaction time of 0.5 to 5 hours.

Can convert waste products resulting from processes such as: pickling, sewage sludge, sulphur dioxide removal system, mining sludges; plating; neutralization; oxidation; precipitation of heavy metals; physical chemical treatment processes; tannery operations; organic manufacturing; paint and pigment manufacturing; and polymer manufacturing.

The inert product formed by this method is used as a soil substitute which will support grass growth and will not leach any of the absorbed wastes to the surrounding environment.

Reference: U.S. Patent 4 149 968.

STATUS OF DEVELOPMENT AND USAGE – Patented concept. Usage not documented for spills of hazardous materials.

PERFORMANCE – Evaluation data not obtained.

AVAILABILITY AND COMMERCIAL INFORMATION –

Mr. A.R. Kupiec
Environmental Technology Corp.
Suite 200
1517 Woodruff Street
Pittsburgh, PA 15220
U.S.A.
Telephone (412) 431-8586

Mr. E.D. Escher
289 Casa Drive
Pittsburgh, PA 15241
U.S.A.

OTHER DATA – None obtained.

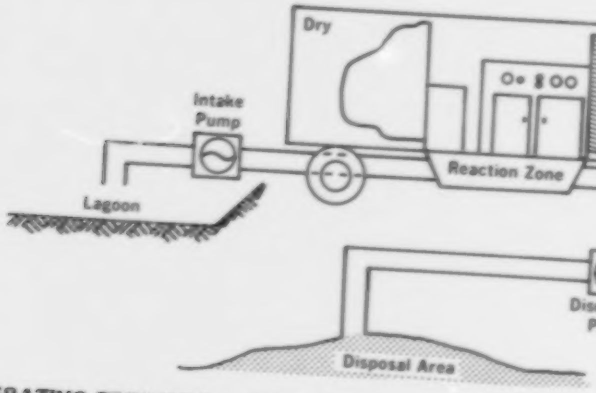
PRODUCT CHEMFIX PROCESS

No. 134

APPLICABILITY

Gas	Liquid Sol	Liquid Fl	Liquid Sk	Solid Sol	Solid Fl	Solid Sk
	*	*	*	*	*	*

DESCRIPTION – Inorganic chemical additives (cements and soluble silicates) are mixed with wastes to produce a gelling reaction that is followed by hardening. This process can be applied in fixed installations or mobile treatment plants with capacities of 1 000 000 L (264 000 U.S. gal) per 10-hour shift.



OPERATING PRINCIPLE – Soluble silicates and silicate setting agents are used to chemically fix polyvalent metal ions and other liquid waste products in an inert stable matrix. The process involves a two-stage reaction: in the first stage, the soluble silicates react with metal ions and other wastes to form insoluble metal silicates, etc. and in the second stage, the setting agents undergo reaction with the soluble silicates to form a gel which entraps and immobilizes ions, oils, etc. This gel hardens to a soil or rock-like inert substance.

PHYSICAL SPECIFICATIONS – Typical operating unit is a mobile van 12.2 m (40 ft) long by 2.4 m (8 ft) wide containing chemical storage as well as metering and mixing equipment capable of process flowrates of 1136 to 1893 L/min (300-500 U.S. gpm) at ambient temperature and pressure.

OPERATING SPECIFICATIONS – Can treat 21 L/s sludge. Cannot treat wastes containing certain unspecified organic compounds and/or toxic anions; however, in some cases, pretreatment will allow fixation of these compounds.

STATUS OF DEVELOPMENT AND USAGE – Chemfix-processed wastes have been approved in a number of U.S. states by regulatory agencies for disposal in standard landfill operations and also in sanitary refuse landfills. Commercial use of this approach now exceeds 12 years. It has been applied to wastes from the petrochemical, steel, chemical, textiles, automotive, refining, electronics, electric utility and metal finishing industries as well as experimentally to sewage, pulp and paper effluents, sanitary landfill and dredging spoils.

PERFORMANCE – Extensive field testing was conducted on the stability of the silicate matrices formed in the process. Leaching tests were conducted to determine if the heavy metal silicates in the matrix would solubilize and escape to the environment. Results of this testing showed that the process reduces the long-term adverse effects of the heavy metals.

AUTOMOTIVE PARTS PLANT (Michigan)

Chemfixed Metal Finishing Waste (5 680 000 Litres Treated)

		Centimetres of Leachate Water				
Constituent (mg/L)	Raw Sludge	0 to 8	8 to 16	16 to 24	24 to 32	32 to 40
Magnesium (Mg)	2300	0.12	<0.10	<0.05	<0.025	<0.025
Nickel (Ni)	1875	0.11	<0.10	<0.025	<0.025	<0.025
Total Chromium (Cr)	2760	<0.10	<0.10	<0.05	<0.05	<0.025
Zinc (Zn)	870	<0.50	<0.025	<0.10	<0.025	<0.025
Copper (Cu)	955	<0.05	<0.05	<0.025	<0.025	<0.025
Iron (Fe)	2160	0.43	0.18	<0.025	0.11	0.19

AVAILABILITY AND COMMERCIAL INFORMATION –

Chemfix Technologies Incorporated
1675 Airline Highway
P.O. Box 1572
Kenner, LA 70063
U.S.A.
Telephone (504) 467-2800

OTHER DATA – Chemfix is a patented process registered with Chemfix Technologies Incorporated.

References: Salas, R.K., Disposal of Liquid Wastes by Chemical Fixation/Solidification -The Chemfix Process, Toxic and Hazardous Waste Disposal, Volume I (ed., R.B. Pojasek), Ann Arbor Science, Publishers Inc. (1979).

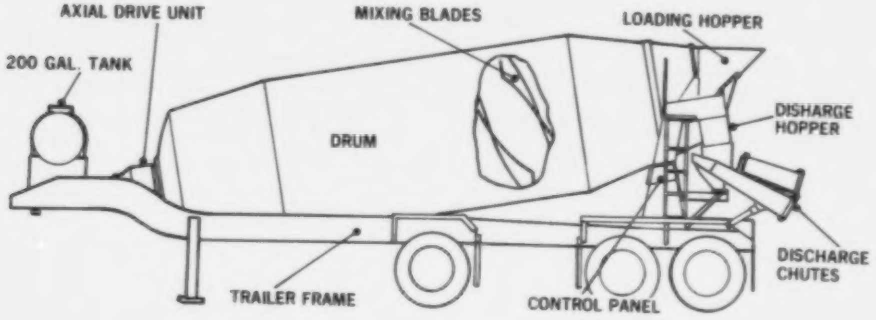
Manufacturer's Literature; U.S. EPA: Guide to the Disposal of Chemically Stabilized and Solidified Waste, SW-872, pp. 74 (September, 1980).

PRODUCT EPS MOBILE PROCESSING AND TRANSFER UNIT **No. 135**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*	*	*	*

DESCRIPTION – These are trailer or truck-mounted mixing units in which hazardous materials can be mixed with chemicals (e.g., solidification agents, neutralizing agents) while being transferred to a disposal site or stationary facilities for further processing.



OPERATING PRINCIPLE – Liquid or solid waste materials are batch-mixed with treating agents or other "co-disposable" wastes by mixing blades inside a rotating drum similar to a cement mixing truck.

PHYSICAL SPECIFICATIONS – Environmental Processing Systems (EPS) Inc. manufactures various capacity trailers and truck-mounted units as well as units custom-built to customer specifications. For example, the 19 m^3 (25 yd^3) unit has the following specifications:

Length	10.8 m	35.5 ft
Width	2.4 m	8 ft
Height	3.9 m	13 ft
Capacity	19 m^3	25 yd^3
Dry Weight	10 206 kg	22 500 lb

757 L (200 U.S. gal) tank supplied with trailer for additional water or liquids required in the mixing drum.

Triple reduction, self-aligning axial drum drive.

Drums and Mixing Blades: abrasion-resistant steel, fully butt-welded, inside and out.

Trailer Frame: high strength steel with Neway Trailer suspension and Granning High Lift Pusher suspension.

Exterior of drum and frame painted with one coat of primer plus a finishing coat of corrosion-resistant Imron paint.

Wide hopper and drum opening for fast loading and unloading.

Hydraulically-operated chute lifter with seven position spring loaded "pin and lever" type chute swing lock.

OPERATING SPECIFICATIONS – Trailer units can be detached and coupled to stationary power systems (electrically-driven hydraulic power unit available as an option).

Drum rotation controlled to 0 to 16 rpm.

Wastes and additives are most conveniently loaded from overhead hoppers or conveyors.

STATUS OF DEVELOPMENT AND USAGE – Standard and custom-designed units are marketed for processing wastes such as municipal sewage sludge cake, flue dust, asbestos wastes, carbon wastes, and air control residues.

PERFORMANCE – Documented performance with hazardous materials was not obtained.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Michigan Disposal
P.O. Box 5116
Dearborn, MI
U.S.A. 48128

OTHER DATA – Stationary waste treatment methods requiring mixing, such as fixation (solidification, encapsulation), carbon adsorption or neutralization, could be readily adapted to the EPS and other mobile mixing units.

PRODUCT TRIPAK LIQUID SOLIDIFICATION COMPOUND **No. 136**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – A gelling compound used to solidify organic liquids for safer handling.

OPERATING PRINCIPLE – Waste organic liquids are poured into a drum containing the gelling agent and agitated to promote solidification. The compound could also be spread over a spill and the resulting solid more easily handled.

PHYSICAL SPECIFICATIONS –

TRIPAK-I: Liquid Solidification System for most organic liquids. One 208 L (55 U.S. gal) drum containing gelling agent. $44.50 U.S. (September, 1983)

TRIPAK-II: Corrosive Liquid Solidification System. One 208 L (55 U.S. gal) drum containing gelling agent to solidify corrosive compounds. $49.50 U.S (September, 1983)

TRIPAK Solidification Media: 22.7 kg (50 lb) bag: $7.50 U.S. (September, 1983)

OPERATING SPECIFICATIONS – Only compatible liquids should be solidified in the same drum, e.g., aromatics should be separate from aldehydes.

STATUS DEVELOPMENT AND USAGE – Widely used by the manufacturer as part of its spill cleanup service.

PERFORMANCE – Use with hazardous materials has not been formally documented. Contact the manufacturer.

AVAILABILITY AND COMMERCIAL INFORMATION – TRIPAK solidification systems are normally available only through contract services from TRI, but could be sold separately through special arrangements.

Triangle Resource Industries (TRI)
14201 Laurel Park Drive
P.O. Box 370
Laurel, MD 20707
U.S.A.
Wash: Telephone (301) 953-9583
Balt: Telephone (301) 792-7507
Telephone 1-800-638-4440
Contact: Ruth Elwell

GSX Service Inc.
3527 Whukey Bottom Road
Laurel, MD 20707

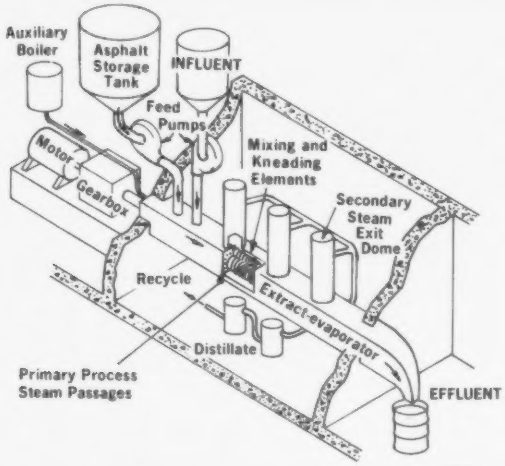
OTHER DATA – TRI is a full-service hazardous materials company, providing emergency spill cleanup and recovery, laboratory support, and hazardous materials program management.

PRODUCT VOLUME REDUCTION AND SOLIDIFICATION SYSTEM (WPC-VRS) **No. 137**

APPLICABILITY

Gas	Liquid Sol	Liquid Fl	Liquid Sk	Solid Sol	Solid Fl	Solid Sk
	*	*	*	*	*	*

DESCRIPTION – The Volume Reduction and Solidification (VRS) system is a one-step, non-chemical process for treatment of solids and liquids. The system removes the water, mixes the materials with asphalt and produces an encapsulated solid as an end-product. It was originally designed for radioactive wastes, but can be made mobile and applied to other hazardous materials.



OPERATING PRINCIPLE – Liquid hazardous wastes are fed to an extruder-evaporator that evaporates water out, while simultaneously mixing and kneeding the waste salts into an asphalt binder. Waste salts are reduced in size to approximately 20 μm and each particle is individually coated with asphalt within the homogeneous mix. In the process, the volume is reduced by a factor of five or more.

The entrained liquid that is evaporated up through the steam domes is recycled back to the plant. The homogeneous mix of asphalt and waste is discharged into a container for ultimate disposal. The ultimate disposal and/or use of the filled container is the deciding factor on the configuration and type of container that is used.

PHYSICAL SPECIFICATIONS –

Complete enclosed system includes:

Collection and feed systems, extruder-evaporator component, processing, discharge and containment, container handling systems and remote control instrumentation.

Containers for solid waste:

Standard 208 L (55 U.S. gal) drums
1.4 to 13 m^3 (50 to 400 ft^3) liners
Fibreboard containers
Other specialty forms

OPERATING SPECIFICATIONS –

Processing capabilities of 9 to 1 816 kg/h (4 000 lb/hr).

Ratio of binder-to-waste is predetermined to maintain an end product of 60% waste salts and 40% asphalt by weight.

Process waste of: Heavy metal, electroplating waste sludges, slurries, evaporator concentrates, radioactive wastes, ion exchange resins, chemical drains, sludges, manufacturing residues, etc.

STATUS OF DEVELOPMENT AND USAGE – Commercially available and marketed to safely dispose of radioactive wastes and hazardous materials. WPC-VRS systems installed in Research Centres, Fuel Processing Centres and Nuclear Power Plants include:

VRS Installations	Number of Units	Delivery/ Start-up Date
CEA, Marcoule, France	2	1965
CEA, Cadarache, France	1	1969
Karlsruhe, West Germany	2	1972-1973
Borssele (PWR), Holland	1	1974
Atucha (PHWR), Argentina	1	1974
Eurochemic, Mol, Belgium	1	1976
Neckarwestheim (PWR), West Germany	1	1976
AECL, Chalk River, Canada	1	1977
Unterweser (PWR), West Germany	1	1977
Goesgen (PWR), Switzerland	1	1978
Laguna Verde (BWR), Mexico	2	1978
Japan	2	1978-1979
Midland (PWR), United States	1	1978
France (Reprocessing Plant)	1	1979
Skagit (BWR), United States	1	1980
Iran I & II, Iran	2	1980-1982

PERFORMANCE – Tests for EPA (1978) - JBF Scientific of Wilmington, MA conducted a study for the fixation of arsenic wastes in asphalt; result - asphalt encapsulation process provided acceptable end products.

Tests conducted on encapsulation of heavy metals that were absorbed on powdered activated charcoal as a black, pasty wet (70% moisture) sludge containing Cd, Cr, Cu, Mn, Pb, Ni and Zn; leach analysis showed over 99% of each of the metals were retained in the asphalt.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Werner & Pfleiderer Corporation
663 East Crescent Ave.
Ramsey, NJ 07446
U.S.A.
Telephone (201) 327-6300
Contact: Manager of Hazardous Waste Treatment Systems

Costs: Costs of treating wastes (by the WPC-VRS System): $20 to $70 per ton (U.S.)
Total cost (includes treating, transportation and burial): U.S. $26 to $75 per ton (May, 1980).

TYPICAL ANNUAL COST SAVINGS
(May 1980, U.S. Dollars)

		Case 1*		Case 2**	
		WPC-VRS	Alternate	WPC-VRS	Alternate
Total Waste Input	(kg/day)	$ 10 886	$ 10 886	$ 1 316	$ 1 361
Dry Solids Input	(kg/day)	2 722	2 722	544	544
Encapsulating Agent	(kg/day)	1 814	N/A	363	N/A
Total Waste Out	(kg/day)	4 536	10 886	907	1 361
Cost of Binder	($/kg)	0.04	N/A	0.04	N/A
	($/yr)	112 000	N/A	22 400	N/A
Cost of Container	($/unit)	0.75	N/A	0.75	15
	($/yr)	8 800	N/A	1 750	53 950
Utility Costs	($/yr)	25 000	N/A	10 000	N/A
Cost of Transportation and Disposal	($/ton)	10	75	10	274
	($/yr)	17 500	315 000	3 500	144 000
TOTAL OPERATING COST	($/yr)	$163 300	$315 000	$ 37 650	$197 950
TOTAL OPERATING SAVINGS	($/yr)	$151 700	—	$160 300	—

* Case 1 is heavy metals adsorbed on powdered activated charcoal. The present alternate filtercake material is hauled off in bulk and solidified at disposer's site.

** Case 2 is arsenic waste from phosphoric acid production. Waste sludge is sealed in metal containers and shipped to secure burial.

OTHER DATA – System may be used with remote operation and isolation for highly toxic material (e.g., radioactive wastes).

Reference: Manufacturer's Literature.

5.3 Physical/Chemical Methods

PROTOTYPE ACUREX PCB DESTRUCTION PROCESS **No. 138**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
		*	*			

DESCRIPTION – Prototype. A mobile, batch-process system designed to dechlorinate PCBs and PCB-contaminated oil with a proprietary sodium reagent. The system consists of a filter (for large solids), surge tank, water filter, reagent tank, reactor tanks, quench tank, a coalescing filter, control panel and a lab.

OPERATING PRINCIPLE – The PCBs or PCB-contaminated transformer oil enters the system at one end where it is filtered and batch sized. As the oil is transferred farther downstream, the active sodium reagent is added and the mixture allowed to react. After complete destruction of PCBs, the excess reagent is quenched. The PCB-free oil is then filtered and returned for reuse. This destruction process takes place under an inert nitrogen atmosphere at ambient temperature.

PHYSICAL SPECIFICATIONS – The system is self-contained and mounted on a 10.6 m (35 ft) trailer.

OPERATING SPECIFICATIONS –

Approximate flow rate of system: 0.3 L/s.
Operated at ambient temperature.
Process takes place under inert nitrogen atmosphere.

Waste products from system:

- Small amounts of nitrogen and hydrogen with less than 1 g/min total hydrocarbon, no measurable PCB and no particulates.
- PCB-free oil.
- Sodium hydroxide solution containing some sodium chloride.

Waste transformer oil containing up to 1000 mg/L PCBs can be treated.
Gas chromatography analysis of effluent determines complete destruction of PCBs.

STATUS OF DEVELOPMENT AND USAGE – Two mobile units are currently in operation in the U.S.

PERFORMANCE – Tests performed for EPA to gain approval and operating permit (9 September 1981) indicated that up to 989 mg/L PCBs in oil were effectively destroyed this process; effluent concentration >2 mg/L (detection limit of analysis) was achieved and no harmful by-products were produced.

Treatment of PCBs up to 10 000 mg/L has previously been achieved.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Acurex Waste Technologies, Inc.
8194 Beechmont Avenue
Cincinnati, OH 45230
U.S.A.
Telephone (513) 474-4420
Contact: Mr. Leo Weitzman

OTHER DATA – Cost of treatment was estimated to be $3/kg in February 1982. This process is a modification of the Goodyear sodium naphthalide reagent process in which the reagent has been replaced by a non-priority pollutant which the company regards as a proprietary constituent.

Reference: Manufacturer's Literature

M.M. Dillon Ltd., Destruction Technologies for Polychlorinated Biphenyls (PCBs), Report EPS 3-EC-83-1, Environment Canada, Ottawa, Ontario, February, 1983 (July, 1983 reprint).

Mr. L. Weitzman, personal communication, Acurex Waste Technologies (February 11, 1982) (June 14, 1984).

CONCEPT THE BROMINATION PROCESS **No. 139**

APPLICABILITY	Gas	Liquid			Solid		
		Sol	Fl	Sk	Sol	Fl	Sk
		*					

DESCRIPTION – A wet oxidation concept effective in the destruction of organics and the separation of hazardous metallic compounds from combustible hazardous materials.

OPERATING PRINCIPLE – An organic material is reacted with bromine and water at an elevated temperature producing carbon dioxide (which is purified and released to the atmosphere), hydrobromic acid and other compounds. These other compounds are formed by the reaction of bromine or water with any metals present in the hazardous organic. The hydrobromic acid formed is electrolyzed to hydrogen and bromine; the hydrogen is retained for use or is burned off and the bromine is recycled to the oxidation step. The metal compounds formed are converted to stable salts or free metals which may be disposed of or used in some other manner.

PHYSICAL SPECIFICATIONS – None obtained.

OPERATING SPECIFICATIONS – Reaction run at 250° to 300°C (482° to 572°F). Concentrations of bromine and water required for conversion of hazardous organics to carbon dioxide + hydrogen + bromine vary with the type of organic compound present in the hazardous material. Reaction time also varies with type of hazardous material.

STATUS OF DEVELOPMENT AND USAGE – Usage not documented on spills of hazardous materials.

PERFORMANCE – Laboratory testing conducted by the U.S. EPA on the bromination of malathion, copper acetate and trichloroethane spills showed substantial destruction of the materials by this method:

Tests With Copper Acetate

Tests conducted at 250° and 300°C (482° and 572°F) for 30 minutes with a bromine/copper acetate initial mole ratio 10:1.

Reaction proceeds as follows:

$$Cu\,(C_2H_3O_2)_2 + 4H_2O + 8Br_2 \longrightarrow 4CO_2 + 14Br + CuBr_2$$

Maximum hydrobromic acid yield (36%) obtained when the water/copper acetate mole ratio was 36:1.

Tests With Malathion

Tests conducted at 300°C for 1 hour with an initial bromine/malathion mole ratio of 40:1.

Reaction proceeded as follows:

$$C_{10}H_{19}O_6PS_2 + 26H_2O + 32Br_2 \rightarrow 10CO_2 + 64Br + 2H_2SO_4 + H_3PO_4$$

A hydrobromic acid yield of 88% was obtained with a water/malathion mole ratio of 600:1.

Malathion destruction was >99.999%.

A pilot-scale bromination system was constructed and tested for the destruction of malathion.

Pilot-scale system consisted of:

an 8 L tantalum-lined autoclave;
a steam generator for injection stirring;
valves;
temperature controls; and
a pressure gauge.

Operated at 300°C and 17 000 kPa pressure.

Results of Pilot-scale Bromination Test

Feedstock	50 g, consisting of: Malathion 70 wt % Sand 10 wt % Humus 5 wt % Moisture 5 wt %
Temperature	296°C
Duration	2 h
CO_2 Product	Expected: 1.06 g-mol Found: 1.07 ± 0.01 g-mol
HBr Product	38 wt % aqueous HBr Expected: 6.94 g-mol
Malathion Residuals	Gas Phase: Not detected, 0.5 mg/L Liquid Phase: Not detected, 0.5 μg/L
Malathion Destruction	>99.9999%

The solid residue was rinsed with a concentrated aqueous HBr solution. This rinse solution was then added to the liquid phase product.

Tests with Trichloroethane

Conducted at 350°C for 1 hour with an initial bromine/water/trichloroethane mole ratio of 6:172:1.

Reaction proceeded as follows:

$$C_2H_3Cl_3 + 4H_2O + 4Br_2 \rightarrow 2CO_2 + 8HBr + 3HCl$$

In all of the tests the organics were destroyed by bromination yielding reaction end products which are easily treated and disposed of.

AVAILABILITY AND COMMERCIAL INFORMATION –

Research conducted by:

Rockwell International
Atomics International Division
8900 De Soto Avenue
Canoga Park, CA 91304
U.S.A.
Project Director: Mr. A.J. Darnall

Research sponsored by:

EPA
Municipal Environmental Research Laboratory
Edison, NJ 08817
U.S.A.
Contact: Dr. J.E. Brugger

OTHER DATA – Conceptual engineering studies of the costs of large-scale bromination systems have been completed.

Cost of $350 000/disposal unit (May, 1980).

References: EPA Project Information Sheets for Hazardous Materials Spill Research, p. 93 (May, 1980).

Darnall, A.J., Rockwell International: "Bromination Process for Disposal of Hazardous Materials", Proc. 1978 Nat. Conf. on Control of Hazardous Materials Spills, pp. 221-225 (1978).

Darnall, A.J., Rockwell International: "Disposal of Hazardous Chemical Spills by the Bromination Process", Proc. 1980 Nat. Conf. on Control of Hazardous Materials Spills, pp. 411-415 (1980).

PROTOTYPE DEGRADATION BY SUPEROXIDE **No. 140**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*					

DESCRIPTION – A prototype method for converting aliphatic halogenated organic compounds to harmless substances using superoxide ion.

OPERATING PRINCIPLE – An electric current is passed through chemical waste in solution, transforming the oxygen content into superoxide (O_2^-), a form of the molecule that contains one extra electron. The halogenated compounds present are then converted to a harmless form such as carbonates.

PHYSICAL SPECIFICATIONS – No information available.

OPERATING SPECIFICATIONS – Superoxide ion (O_2^-) can be generated using a controlled-potential electrolysis cell with an air-saturated dimethyl sulphoxide-tetraalkylammonium chloride electrolyte.

Halogenated waste such as carbon tetrachloride (CCl_4) is added to the cell, producing carbonate ion (CO_3^{2-}) and dimethyl sulphone ($(CH_3)_2SO_2$).

For chloromethane substances, one or more O_2^- ions per chloride may be consumed to yield oxygenated products for complete reaction.

Not suitable for cleanup of contaminated groundwater.

STATUS OF DEVELOPMENT AND USAGE – Usage not documented for spills of hazardous materials.

PERFORMANCE – CCl_4, $CHCl_3$, CH_2Cl_2, CH_3Cl and p,p^1 - DDT react rapidly with superoxide ion in dimethylformamide (DMF) and dimethyl sulphoxide ($(CH_3)_2SO$).

Fastest displacement reactions were observed when CCl_4 and $CHCl_3$ reacted with O_2^- ion.

AVAILABILITY AND COMMERCIAL INFORMATION –

Office of the Board of Patents
University of California
Systemwide Administration
491 University Hall
Berkeley, CA 94720
U.S.A.
Telephone (415) 642-5000
Contact: Mr. M.G. Petit
Licensing Associate

OTHER DATA – No other information obtained.

Reference: Roberts, J.L., Jr., D.T. Sawyer, Department of Chemistry, University of California, Riverside, California 92521, Facile Degradation by Superoxide Ion of Carbon Tetrachloride, Chloroform, Methylene Chloride, and p,p^1-DDT in Aprotic Media (September 2, 1980).

PROTOTYPE LARC (LIGHT ACTIVATED REDUCTION OF CHEMICALS) PROCESS **No. 141**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – Prototype. The LARC (Light Activated Reduction of Chemicals) process uses ultraviolet (UV) light and hydrogen to dehalogenate chlorinated, brominated or iodinated organics.

OPERATING PRINCIPLE – The ultraviolet light initiates a photochemical reaction which, in the treatment of PCBs, results in the cleavage of the carbon-chlorine bond and the formation of a carbon-hydrogen bond. Degradation products, including chlorides and biphenyl, produced during the reaction are analyzed by gas chromatography and the process is allowed to continue until the required dehalogenation is achieved.

PHYSICAL SPECIFICATIONS – Two LARC reactors were used during preliminary phases of research:

PERTINENT REACTOR PARAMETERS

	Tube Unit	Pilot Unit
Number of Lamps	1	64
Capacity	600 mL	40 L
Light Path Length	5.33 mm	6.35 mm
Radiant Energy at Lamp Sleeve Surface	36 300 $\mu W/cm^2$	29 400 $\mu W/cm^2$
Hydrogen Flow Rate	0.26 L/min	1.9 L/min
Type of Operation	- flow through or batch recycle	- flow through or batch recycle

Using the single lamp unit, a Varian 3700 gas chromatograph was used for product analysis along with a computer controller/integrator in tests conducted on PCBs and Chlordane.

	PCBs	Chlordane
Column	3.7 m x 2 mm I.D. glass packed with 1.5% SP-2250/1.95% SP-2401 on Supelcoport	60 m x 0.75 mm I.D. capillary with SE-54 bonded phase

OPERATING SPECIFICATIONS – For the PCB and Chlordane tests:

	PCBs	Chlordane
Carrier gas	N_2 at 20 mL/min	He @ 5 mL/min N_2 makeup @ 50 mL/min
Injector temp.	270° C	270° C
Detector	^{63}Ni @ 300° C	^{63}Ni @ 300° C
Oven	180° C for 1 minute, then programmed at 10° C/min to 240° C (hold for 20 min)	180° C for 3 minutes, then programmed at 6° C/min to 240° C (hold for 25 min)

The UV lamps are low pressure with 95% of their output at 2537A°.

STATUS OF DEVELOPMENT AND USAGE – Laboratory studies have been conducted on chlorinated organics extracted from contaminated soils. These have been used as the basis for a proposed mobile unit for spill response. A process schematic has been produced and the equipment involved envisioned as being mounted in a standard trailer. Two extraction units would be used to remove contaminants from the soil which would then be vacuum stripped of residual solvent and returned to the environment. The concentrated chlorinated organics would be stored in a surge tank.

PERFORMANCE – Laboratory studies have achieved the following results with the single lamp unit:

(1) Extraction data for chlorinated organics from soils

	Aroclor 1260		Chlordane	
	Dry soil	Wet soil	Dry soil	Wet soil
Initial concentration (mg/kg)[1]	487	486	724	724
Weight of soil (g)	330	330	339	313
Amount removed from soil in first extraction (mg/kg)[1]	337	268	403	437
Solvent recovered from first extraction (mL)	320	360	339	485
Amount removed from soil in second extraction (mg/kg)[1]	113	131	172	111
Solvent recovered from second extraction (mL)	420	410	500	520
Final concentration in extracted soil (mg/kg)[1]	38	50	37	35
Overall extraction efficiency (percent)	92	90	95	95

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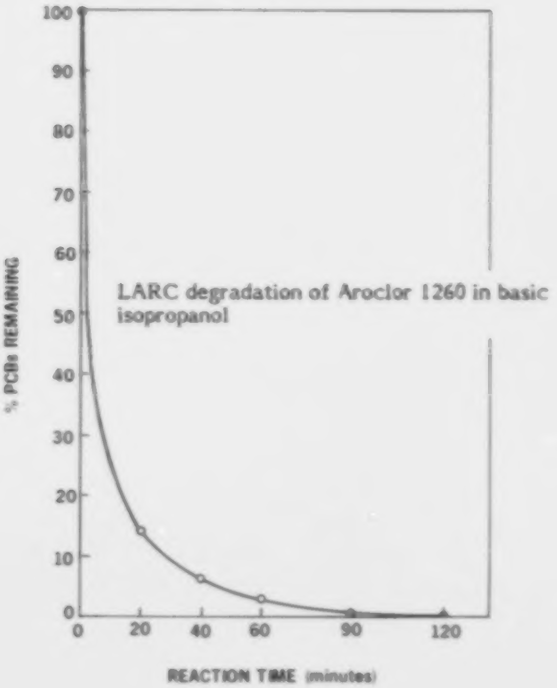
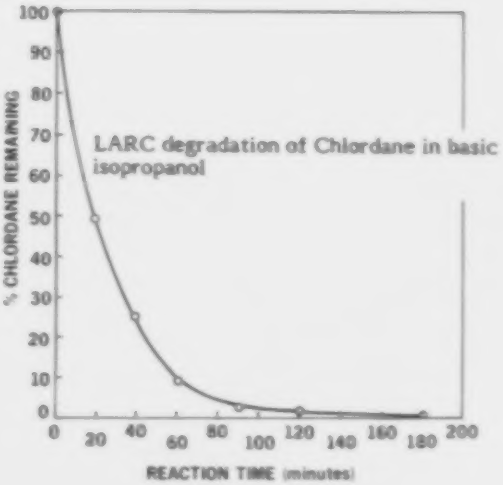
[1] All concentrations based on dry weight of soil

(2) Results of the LARC degradation



LARC degradation of Aroclor 1260 in basic isopropanol



LARC degradation of Chlordane in basic isopropanol

AVAILABILITY AND COMMERCIAL INFORMATION – Information on the LARC process can be obtained from:

Developer:

Atlantic Research Corporation
5390 Cherokee Ave.
Alexandria, VA 22314
U.S.A.
Telephone (703) 642-4000
Contact: Ms. J.F. Kitchens
Manager, Environmental Sciences and Engineering Division

Cost Estimates (published April 1984):

At an average PCB soil concentration of 1500 mg/kg, total costs (including capital expenses, daily operating costs, labour, analytical work, travel, per diems, and profit) were estimated to be $84.60 (U.S.)/ton of soil.

OTHER DATA – References used in the compilation of this entry should be consulted for additional information:

References: Kitchens, J.F., B.L. Anspach, L.B. Mangoba, and E.A. Kobylinski, "Cleanup of Spilled Chlorinated Organics with the LARC Process", Proceedings of the 1984 Hazardous Materials Spills Conference, Nashville, TN (April 9-12, 1984).

M.M. Dillon Ltd., Destruction Technologies for Polychlorinated Biphenyls (PCBs), Report EPS 3-EC-83-1, Environment Canada, February, 1983 (reprinted July, 1983).

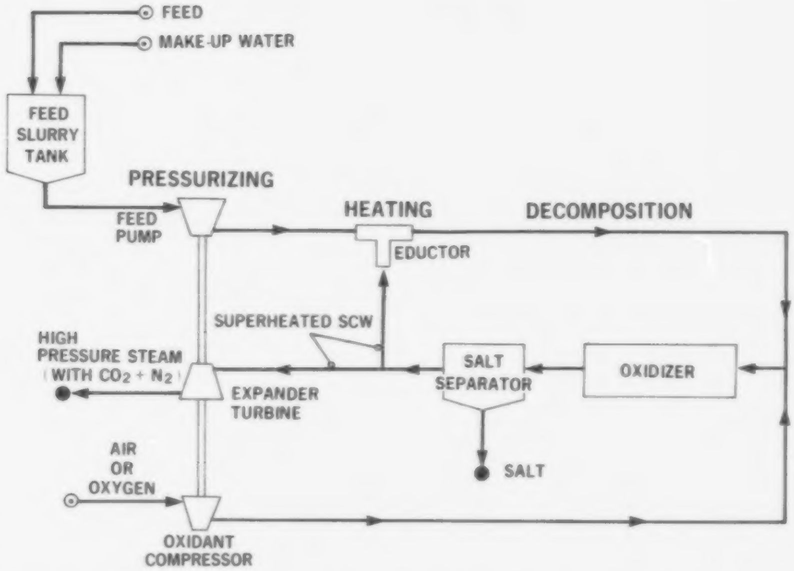
CONCEPT MODAR SUPERCRITICAL WATER OXIDATION PROCESS **No. 142**

APPLICABILITY

Gas	Liquid			Solid	
	Sol	Fl	Sk	SoFl	Sk
	*	*	*	*	

Note: Applicable to liquids and solutions of soluble solids.

DESCRIPTION – Concept. The MODAR process destroys hazardous organic materials by their oxidation in water in its supercritical state (SCW).



OPERATING PRINCIPLE – Hazardous materials are slurried with makeup water to a mixture of 5 to 10% by weight. The slurry is pressurized and heated to supercritical conditions (i.e., above 374°C and 22 100 kPa). Heating is achieved by mixing the slurry with treated supercritical water. During a residence time of less than one minute in the tubing before the oxidizer, organics are converted to combustible gases (e.g., CO, H_2, CH_4) and volatile liquids (e.g., furans, furfurals, alcohols, aldehydes); and inorganics are converted to inorganic salts. (Some base is added so that anions will salt out.) Air or oxygen introduced through the oxidizer is completely miscible in the supercritical solution, allowing for a rapid, exothermic oxidation reaction to occur. For feeds of greater than 5 % organics by weight, the heat of combustion is sufficient to raise the oxidizer effluent to at least 550°C. Above 500°C, the solubility of inorganic salts is extremely low and therefore readily separated as a solid slurry. The final superheated SCW (containing some CO_2 and N_2) is available for preheating the feed to the oxidizer, power generation, or use as high-pressure steam (>500°C, 25 500 kPa absolute (>900°F, 3700 psia)).

PHYSICAL SPECIFICATIONS – Only a bench-scale system has been developed for testing. The reactor was constructed from Hastelloy C-276 with an inside diameter of 22.3 mm (0.88 in) and a length of 61 cm (2 ft) and processed 4 L/day (1 U.S. gal/day).

OPERATING SPECIFICATIONS – Not available.

STATUS OF DEVELOPMENT AND USAGE – The Modar process is based on research by Dr. Michael Modell and co-workers in 1975. The company Modar was formed in 1980 to develop and commercialize the SCW oxidation process. To date, only bench-scale tests have been reported. Pilot plant tests were scheduled for 1982-83.

PERFORMANCE – Bench-scale tests sponsored in 1981 by the U.S. Army Medical Bioengineering Research and Development Laboratory and the EPA's Office of Research and Development showed >99.99% destruction was obtained for a variety of organic chlorides.

Summary of Results: Oxidation of Organic Chlorides

Run No.	11	12	13	14	15
Residence Time (min)	1.1	1.1	1.1	1.1	1.3
Carbon Analysis:					
Organic Carbon In (ppm)	26 700	25 700	24 500	38 500	33 400
Organic Carbon Out (ppm)	2.0	1.0	6.4	3.5	9.4
Destruction Efficiency (%)	99.993	99.996	99.975	99.991	99.97
Combustion Efficiency (%)	100	100	100	100	100
Gas Composition:					
O_2	25.58	32.84	37.10	10.55	19.0
CO_2	59.02	51.03	46.86	70.89	70.20
CH_4	—	—	—	—	—
H_2	—	—	—	—	—
CO	—	—	—	—	—
Chloride Analysis:					
Organic Chloride In (ppm)	876	1266	748	775	481
Organic Chloride Out (ppm)	.023	.037	<.028	.032	.036
Organic Chloride Conversion (%)	99.997	99.997	99.996	99.996	99.993

$$\text{Destruction Efficiency} = \frac{\text{Organic Carbon IN - Organic Carbon OUT}}{\text{Organic Carbon IN}} \times 100$$

$$\text{Organic Chloride Conversion} = \frac{\text{Organic Chloride IN - Organic Chloride OUT}}{\text{Organic Chloride IN}} \times 100$$

Composition of Feed Mixtures

		wt %	wt % Cl
Run 11			
DDT	$C_{14}H_9Cl_5$	4.32	2.133
MEK	C_4H_8O	95.68	—
		100.0	2.133
Run 12			
1,1,1-trichloroethane	$C_2H_3Cl_3$	1.01	0.806
1,2-ethylene dichloride	$C_2H_2Cl_2$	1.01	0.739
1,1,2,2-tetrachlorethylene	C_2Cl_4	1.01	0.866
o-chlorotoluene	C_7H_7Cl	1.01	0.282
1,2,4-trichlorobenzene	$C_6H_3Cl_3$	1.01	0.591
Biphenyl	$C_{12}H_{10}$	1.01	—
o-xylene	C_8H_{10}	5.44	—
Methyl Ethyl Ketone (MEK)	C_4H_8O	88.48	—
		100.0	3.284

Composition of Feed Mixtures (Cont'd)

		wt %	wt % Cl
Run 13			
Hexachlorocyclohexane	$C_6H_6C_6$	0.69	0.497
DDT	$C_{14}H_9Cl_5$	1.00	0.493
4,4'-dichlorobiphenyl	$C_{12}H_8Cl$	1.57	0.495
Hexachlorocyclopentadiene	C_5Cl_6	0.65	0.505
Methyl Ethyl Ketone (MEK)	C_4H_8O	96.09	—
		100.0	1.99
Run 14			
PCB 1242	$C_{12}H_xCl_{4-6}$	0.34	0.14
PCB 1254	$C_{12}H_xCl_{5-8}$	2.41	1.30
Transformer oil	$C_{10}-C_{14}$	29.26	—
Methyl Ethyl Ketone (MEK)	C_4H_8O	67.99	—
		100.0	1.44
Run 15			
4,4'-dichlorobiphenyl	$C_{12}H_8Cl$	3.02	.96
Methyl Ethyl Ketone (MEK)	C_4H_8O	96.98	—
		100.0	0.96

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Modar Incorporated
14 Tech Circle
Natick, MA 01760
U.S.A.
Telephone (617) 655-7741
Contact: Mr. Michael Modell, President

The MODAR SCW Oxidation Process is patented under U.S. Patent No. 4 113 446, Sept. 12, 1978.

OTHER DATA – Cost estimates for large-scale facilities are difficult to determine from bench-scale systems. Tentative estimates in 1981 of the capital cost for a 10 000 L/day system were approximately $5 200 000 (U.S.) with processing costs of $0.13 to 0.53 minimum for each kg of organic liquid destroyed. These costs could decrease when pilot plant results are considered along with the potential energy source of the process effluent.

References: Modell, M. et al., "Supercritical Water: Testing reveals new process holds promise," Solid Wastes Management. 76, pp. 26-30 (August, 1982).

Destruction Technologies for Polychlorinated Biphenyls (PCBs), prepared by M.M. Dillon Ltd., Toronto, for the Waste Management Branch, Environment Canada, Reprint July, 1983, Report No. EPS 3-EC-83-1.

Also see reference under "PERFORMANCE"

PROTOTYPE NaPEG™ SYSTEM **No. 143**

APPLICABILITY	Gas	Liquid			Solid		
		Sol	Fl	Sk	Sol	Fl	Sk
				*			

DESCRIPTION – A prototype for dechlorinating PCBs using a sodium polyethylene glycol (NaPEG)™ reagent.

OPERATING PRINCIPLE – The NaPEG™ reagent is added to PCB-contaminated materials on a batch-process basis. The mixture is allowed to react under ambient conditions without the need for an inert atmosphere. After destruction of PCBs, excess reagent is neutralized and the reaction by-products are removed.

PHYSICAL SPECIFICATIONS – No specific information available. The process involves equipment normally available for batch operations: tanks, transfer pumps, mixing chambers, diaphragm control valves, piping construction of compatible material, etc.

OPERATING SPECIFICATIONS – The sodium polyethylene glycol reagent is made by adding sodium to polyethylene glycol at about 100°C (212°F) with stirring. The reaction will not take place if oxygen is absent from the system. The amber reagent is produced almost immediately with the evolution of heat and hydrogen.

Stable for up to two years when stored at room temperature.
Insensitive to air or water and contains no metallic sodium.
Operating temperature during PCB destruction: from ambient to 125°C (257°F).

A batch plant can be constructed from readily available components such as: steel tanks, piping, heaters and chemical process pumps. A stirrer, controller or specific duty pump may have to be purchased.

Reaction by-products include sodium chloride, non-toxic organic compounds and decontaminated material.

Concentrations of PCB in contaminated materials that may be treated, range from trace levels to 100%.

STATUS OF DEVELOPMENT AND USAGE – The NaPEG™ reagents have been primarily applied to the destruction of PCBs and the decontamination of PCB-containing oils. They can more generally be applied to treat halogenated materials. The 1982 draft version of this survey indicated the following areas in which the NaPEG™ method was used on a trial basis:

- dehalogenation of dielectric fluids and oils contaminated with organochlorides;
- reclamation of oil after decontamination;
- decontamination of spills on porous and non-porous surfaces; they can be sprayed on spill reagent areas and allowed to react over an extended period; the excess can be taken up by the soil components or neutralized; products of reaction can be decomposed by normal bacterial action; and
- reclamation of contaminated condensates after decontamination.

The 1982 survey also referred to other potential applications:

- destruction of pesticide and herbicide residues;
- destruction of certain chemical warfare agents containing chlorine or phosphorus; and
- purification of effluents from chemical plants.

A licence for the original NaPEG™ process was granted by the U.S. EPA Region III in October 1982 and has since been similarly approved by the EPA in several other regions. The Franklin Institute has now modified the original process to improve its economics (on a cost per unit volume basis) while still meeting U.S. EPA requirements. EPA approval on a national basis for this modified process will be sought now that tests have been successfully completed at the Philadelphia Electric Company by the Franklin Institute.

PERFORMANCE – Earlier laboratory tests have shown that the NaPEG™ reagents have reduced PCBs to "zero detectable" in a matter of hours.

The more recently conducted evaluation program has verified the effectiveness of the modified process on a more practical basis at the Philadelphia Electric Company.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Franklin Institute Research Laboratory, Inc.
20th and Race Street
Philadelphia, PA 19103
U.S.A.
Telephone 448-1370
Contact: Mr. David M. Kyllonen

OTHER DATA – Process can be adapted easily and inexpensively to requirements of either a portable or stationary batch plant.

The Franklin Institute can supply NaPEG™ reagents to those capable of processing their own oils for cleanup and/or reclamation on-site using relatively simple equipment.

Use of reagents to decontaminate solids, including soils, has also been investigated at a restricted-access dump in Rhode Island and at a contaminated waste site in WI, U.S.A.

NaPEG™ reagent is standardly available in two forms:
NaPEG™ 200 - PEG 200 mixture
NaPEG™ 400 - PEG 400 mixture

NaPEG™ has a shelf-life in excess of two years, is not sensitive to small quantities of air or water, and contains no metallic sodium.

References: M.M. Dillon Ltd., "Destruction Technologies for Polychlorinated Biphenyls (PCBs), Environment Canada, EPS 3-EC-83-1 (February, 1983).

Franklin Institute Research Laboratory Inc. "The Franklin Institute's Chemical Method for Detoxifying Polychlorinated Biphenyls (PCBs) and Other Toxic Wastes."

Mr. David M. Kyllonen, personal communication, Franklin Institute Research Laboratory, Inc. (June 18, 1984).

PRODUCT PPM INC. MOBILE PCB DESTRUCTION PROCESS **No. 144**

APPLICABILITY	Gas	Liquid			Solid		
		Sol	Fl	Sk	Sol	Fl	Sk
				*			

DESCRIPTION – A mobile chemical process for treating PCB-contaminated transformer oil.

OPERATING PRINCIPLE – Contaminated transformer oil is pretreated to remove water, air and other impurities which may interfere with the reacting agent; a proprietary organo-sodium reagent. PCBs and other chlorinated hydrocarbons are converted to end products of sodium chloride, hydrogen and a polyphenylene polymer. The latter is a solid free of PCBs and can be disposed of by accepted methods.

PHYSICAL SPECIFICATIONS – Process equipment mounted on a 12 m (40 ft) trailer. Unit contained in a 4540 L (1200 U.S. gal) spill pan.

OPERATING SPECIFICATIONS – Approximately one 208 L (55 U.S. gal) barrel of polymer is generated for every 40 000 L (10 600 U.S. gal) of oil treated.

STATUS OF DEVELOPMENT AND USAGE – Commercially available from the manufacturer. The process was permitted to operate in all U.S. EPA regions, except Region IX, as of June 1983. One unit has been operated in Regina, Saskatchewan since January 1982.

PERFORMANCE – Environment Canada tests showed the PPM process reduced PCB levels from 260 ppm to less than one ppm for 23 000 L (6000 U.S. gal) of PCB-contaminated tranformer oil stored in Regina, Saskatchewan during 1982.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

PPM Incorporated
Central Avenue
Kansas City, Kansas 66118
U.S.A.
Telephone (913) 621-4206
Contact Mr. Dennis Tapsak, V.P.

or

1875 Forge St.
Tucker, GA 30084
U.S.A.
Telephone (404) 934-0902
Contact: Mr. Louis Centofanti

OTHER DATA – Refer to the latter reference listed above for information regarding other PCB destruction techniques.

References: "Georgia firm successfully destroys PCBs in Canada," Hazardous Spills Intelligence Report, p. 8 (June 3, 1983).

Destruction Technologies for Polychlorinated Biphenyls (PCBs), prepared by M.M. Dillon Ltd., Toronto, Ontario, for the Waste Management Branch, Environmental Protection Service, Environment Canada, Report No. EPS 3-EC-83-1 (July, 1983).

PRODUCT SUNOHIO PCBX PROCESS **No. 145**

APPLICABILITY	Gas	Liquid			Solid		
		Sol	Fl	Sk	Sol	Fl	Sk
				*			

DESCRIPTION – A chemical disposal method that breaks apart and rearranges PCB (polychlorinated biphenyl) molecules in waste oil to form environmentally-safe chemical compounds. This is a portable process which is self-contained in a trailer.

OPERATING PRINCIPLE – The process uses a proprietary chemical reagent to strip the chlorine atoms for the PCBs in waste oil.

PHYSICAL SPECIFICATIONS – The PCBX unit is housed on a large (12 m) (40 ft) tractor/trailer rig. Oil reclaiming equipment and a mobile laboratory are housed on a smaller trailer rig.

OPERATING SPECIFICATIONS – Reagent used in process cannot treat aqueous solutions such as PCB-contaminated groundwater.

Two mobile units operate from any 460 or 230 volt, 60 Hz power source.

Design process capacity for four rigs is 2.3 m^3/h (80 ft^3/h) of transformer oil at a nominal 2000 ppm PCB kill. One of five rigs has slightly higher processing capability.

Spill pans leading to emergency reservoirs are capable of holding one hour of full process flow.

STATUS OF DEVELOPMENT AND USAGE – Recent improvements to the PCBX process have included reducing set-up time from 19 hours to 4 hours for some rigs. Insofar as EPA approval is concerned, the ten EPA designated regions currently have various stipulations for the PCBX process that range from no limitation to 2500 ppm PCBs in the waste being treated as well as, in some cases, limits on feedstock in the reactor loop. A demonstration is being planned by SUNOHIO for EPA in July or August 1984 with 10 000 ppm as the target for a national permit (to be issued at a later date).

PERFORMANCE – Testing conducted by SUNOHIO and verified by the U.S. EPA indicated that the PCBX unit could cleanse "typical transformer oil" contaminated with 255 ppm of PCBs to a level of 1 ppm after single-pass treatment.

Askarel has been treated at a rate of 150 L/min to a PCB content of 7 ppm in the working fluid from a level of 4400 ppm.

In a test conducted from Region V, U.S. EPA in May 1982, transformer oil containing 1760 ppm PCBs was reduced to the limits of detection in three passes.

As of May 1982, about 1 900 000 L of contaminated oil had been treated commercially.

AVAILABILITY AND COMMERCIAL INFORMATION –

SUNOHIO Company
1700 Gateway Boulevard South East
Canton, OH 44707
U.S.A.
Telephone (216) 452-0838
Contact: Dr. Ralph Cooper

OTHER DATA – SUNOHIO, the developer of PCBX, is a partnership of Sun Company and Ohio Transformer Corporation. The company operates five mobile rigs in the U.S.

Capability of the PCBX process can exceed 10 000 ppm although this depends upon the nature of the waste; generally, at higher levels it is not as economical. Therefore practical economic limitations as well as regulatory limitations are examined in concert with the waste in question and client needs when a rig is being considered for use.

References: Dr. Ralph Cooper, personal communication, (June 19, 1984).

M.M. Dillon Ltd., "Destruction Technologies for Polychlorinated Biphenyls (PCBs), Environment Canada, Report EPS 3-EC-83-1 (February, 1983).

"EPA Regions IV and VII approve SUNOHIO Chemical PCB Degradation Process", Hazardous Materials Intelligence Report, pp. 8 (May 29, 1981).

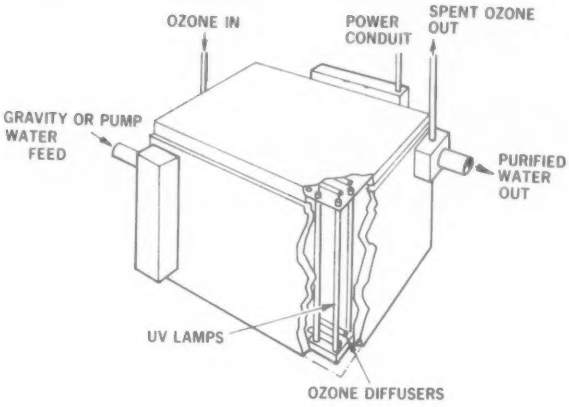
PRODUCT WESTGATE ULTROX (UV-OXIDIZER) PROCESS **No. 146**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*	*		

Note: Applicable to solutions of organic liquids and soluble solids which are low in suspended solids.

DESCRIPTION – Compact, modular reactor units in which oxidizing agents (e.g., ozone) are enhanced by ultraviolet (UV) radiation to remove organic, organometallic and reduced inorganic compounds from solutions.



OPERATING PRINCIPLE – The effective oxidation power of ozone is enhanced by UV radiation which is hypothesized to either photodecompose the organic compounds to more reactive "free radical" species or simply activate them. In the ULTROX process, the contaminated waste water flows between UV lights (similar to fluorescent lamps) in a series of compartments, from the bottom of which ozone is sparged to react with the contaminants. Unused ozone is separated (and decomposed) from the purified effluent which contains mostly end products of water, carbon dioxide and small amounts of intermediates (e.g., acetic and oxalic acids).

PHYSICAL SPECIFICATIONS – Westgate has developed units from bench-scale to full-scale; up to 400 L/min (150 000 U.S. gpd) (Model F1102-100). A portable, skid-mounted pilot plant (Model P-602) is available for testing and economic feasibility evaluations.

Model P-602 Pilot Plant

Length m (ft)	13.7 (45)
Width m (ft)	8.5 (28)
Height m (ft)	13.7 (45)

Reaction Vessel:

- 280 L (75 U.S. gal) wet volume
- 304 stainless steel, passivated and electropolished to reduce chemical corrosion and increase UV reflectivity.
- uses up to 30 forty watt G36TGL, low pressure UV lamps.
- ozone ceramic sparger.

Feed Pump:

- Gear type, seal-less magnetic pump.
- 0.7 to 7.6 L/min (0.2 to 2 U.S. GPM) for vessel retention times of 37 to 375 min.

Westgate proposed a preliminary design for a 227 000 L/day (60 000 U.S. GPD) ozone/UV single stage multicompartment unit transportable on a flatbed trailer.

Length m (ft)	6.4 (21)
Width m (ft)	2.1 (7)
Height m (ft)	1.6 (5)

Stainless steel construction.
Sized for one hour detention time.
336 40 watt UV lamps.
91 kg/day (200 lb/day) ozone generator.

Weight: about 9070 kg (20 000 lb), including wastewater pump, air compressor, ozone generator, reactor, and catalytic ozone converter.

Power: 125 kW diesel generator
22 kW for lights
83 kW for ozone generator

Diesel Generator:

Length m (ft)	2.5 (8.3)
Width m (ft)	0.9 (2.8)
Height m (ft)	1.3 (4.3)
Weight kg (lb)	450 (1000)

OPERATING SPECIFICATIONS – Ozone has been employed most often with ultraviolet light, but other feasible oxidizers include hydrogen peroxide, chlorine dioxide, and chlorine.

Estimated operating and maintenance costs for ULTROX oxidation are:

Ozone Oxidation

Air supplied generators: 12.1 to 16.5 kWh/kg of ozone
Compressor for air: 5 kWh/kg of ozone
Oxygen supplied generators: 6.4 to 8.4 kWh/kg of ozone

Hydrogen Peroxide Oxidation

Approximately $1.32/kg of H_2O_2 (U.S. 1982)
(No operating data were obtained regarding chlorine dioxide or chlorine.)

UV Lamps

Approximately 75 watts/lamp.

In general, the ULTROX process requires little operator attendance when running continuously or intermittently.

STATUS OF DEVELOPMENT AND USAGE – Westgate has been developing the ULTROX process since approximately 1975. Bench-scale and pilot-plant units are available for clients wishing to investigate the feasibility of the process. Full-scale plants have been developed for treating cyanide and organic wastewaters from a tool company, photographic and metal plating waste from a U.S. Army ammunition plant, and a mixture of cyanide and organic nitrogen wastes from a firm in France. The feasibility of the ULTROX has also been demonstrated for treating PCB-contaminated waters from a capacitor fabrication plant and the "pink water" of a U.S. ammunition plant.

List of Organics Determined to be Economically Treatable by the ULTROX O_3/UV Process

Acetaldehyde
Acetic Acid
Alcohols
Aldrin
Amines
Anisole
Benzoic Acid
Chelating Compounds
Chlorinated Phenols
Glycine
Glycols
Hydroquinone
Kepone
Methylene Chloride
Nitrobenzene
Nitrophenol
Organic Phosphates
Organosulphur Compounds
Organo-Tin Compounds
Chlorobenzene
Detergents
Diedrin
Dioctylphthalate
Endrin
Ethylene dichloride
Formaldehyde
Formic Acid
Glycerols
PCBs
Phenol
Phthalic Acid
RDX
Sodium Acetate
Styrene
Sugars
TNT
Vinyl Chloride
Xylenol

PERFORMANCE – Contaminants in groundwater and industrial effluents included:

Industrial Effluents

Pentachlorophenol
Phenol
Methylene chloride
Glycerine
EDTA
Formic Acid
TNT
RDX
Dioctylphthalate
Sodium gluconate
PCBs
Dimethyl furan
Formaldehyde
Photoresist solution
Isopropanol
Acetone
Hydroquinone
Detergents
Toluene
Xylene

Groundwater

Diisopropylmethyl phosphonate (DIMP)
Dicyclopentadiene (DCPD)
Pentachlorophenol (PCP)
Tetrahydrofuran
1,1,1-Trichloroethane
Trichloroethylene
Tetrachloroethylene
Freon-113

Typical Pilot Plant Operating Conditions and Treatment Results

Type of Wastewater	Influent Analysis	Effluent Analysis	Residence Time (min)	Wastewater Flow Rate (L/min)	Oxidant Dosage	No. of UV Lamps
Pink Water	70 mg/L TOC 76 mg/L TNT	5 mg/L TOC 1 mg/L TNT	177	3.8	190 mgO_3/L	29
Groundwater	2.6 mg/L DIMP	12 mg/L DIMP	95	3.8	105 mgO_3/L	29
Industrial	50 µg/L PCB	<1 µg/L PCB	130	2.0	50 mgO_3/L	15
Groundwater	500 mg/L DBCP	<5 mg/L DBCP	100	2.6	1000 mgH_2O_2/L	29
Industrial	3000 mg/L PCP	1.4 mg/L PCP	88	3.0	250 mgO_3/L	30

The following specifications were given for an ULTROX process to treat PCB wastes for General Electric in Hudson Falls, NY based on pilot-plant tests made on site between September and November 1978.

Design Specifications, Capital, and O&M Costs for 150 and 570 m^3/day (4000 and 150 000 GPD) ULTROVOX® Treatment Plants

Design Specifications

Reactor:	150 m^3/day Automated System	570 m^3/day Automated System
Dimensions, L x W x H m	4.9 x 2.4 x 1.5	8.5 x 4.3 x 1.5
(ft)	(16 x 8 x 5)	(28 x 14 x 5)
Wet Volume m^3	15	56
(USG)	(3950)	(14 800)
UV Lamps		
Number of 65 W lamps	378	1179
Total Power, kW	25	80
Ozone Generator:		
Dimensions, ft (H x W x D)	5.5 x 6 x 4	8 x 6 x 10
lb O_3/day	17	63
Total Power, kW	7	26
Total energy required (kWh/day)	768	2544

Capital Costs ($U.S., 1978):

	150 m^3/day	570 m^3/day
Reactor	$ 94 500	$225 000
Generator	30 000	75 000
Total	$124 500	$300 000

O&M Costs/Day ($U.S., 1978)

	150 m^3/day	570 m^3/day
Ozone Generation Power	$ 4.25	$ 15.60
UV Lamp Power	15.00	48.00
Maintenance (Lamp Replacement)	27.00	84.20
Equipment Amortization (10 yrs @ 10%)	41.90	97.90
Monitoring Labour	85.71	85.71
Total/Day	$173.86	$331.41

Costs per 3800 L (1000 U.S. gal)

	150 m^3/day	570 m^3/day
(with monitoring labour)	$ 4.35	$ 2.21
(without monitoring labour)	$ 2.20	$ 1.64

STATUS OF DEVELOPMENT AND USAGE –

Manufacturer:

Westgate Research Corporation
1931 Pontius Ave.
West Los Angeles, CA 90025
U.S.A.
Telephone (213) 473-4541
Contact: Mr. Jack Zeff

OTHER DATA – The estimated total capital cost for the proposed mobile UV/ozone ULTROX unit and diesel electric generator were approximately $265 000 and $20 000 (U.S., 1979), including ancillary equipment (air compressor, ozone generator, reactor with UV lamps, catalytic converter, wastewater pump, piping and valves), engineering and installation fees.

Houston Research, Inc. (Houston, TX) offers a multistage UV/ozone reactor compared to the single-stage, multi-compartment design of Westgate.

References: Arisman, R.K., R.C. Musick, J.D. Jeff and T.C. Crase, "Experience in Operation of a UV-Ozone (ULTROX®) Pilot Plant for Destroying PCBs in Industrial Waste Effluent", 35th Annual Purdue Industrial Waste Conference (May, 1980).

Ghassemi, M., K. Yu and S. Quinlivan (TRW Environmental Engineering), Feasibility of Commercialized Water Treatment Techniques for Concentrated Waste Spills, prepared for U.S. EPA, Report No. EPA -600/2-81-213 (NTIS PB82-108440) (September, 1981).

CONCEPT SODIUM NAPHTHALIDE METHOD FOR DISPOSAL OF PCBs No. 147

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
			*			

DESCRIPTION – A conceptual method for chemically converting PCBs to non-toxic, easily disposed of products using a sodium naphthalide reagent.

OPERATING PRINCIPLE – PCB-contaminated oil is reacted with sodium naphthalide under an inert atmosphere and ambient temperature in either glass or steel vessels.

PHYSICAL SPECIFICATIONS – Not available nor applicable.

OPERATING SPECIFICATIONS – Sodium naphthalide is formed by heating sodium with heat-transfer fluid in an inert atmosphere to 150 to 170°C for 5 to 10 minutes with stirring, cooling, and reacting the resulting fine spheres of sodium with a tetrahydrofuran solution of naphthalene in heat-transfer fluid at ambient temperature to form greenish-black sodium naphthalide. Sodium naphthalide is added to PCB-contaminated heat-transfer fluid in sufficient amount to yield a sodium naphthalide reagent/chlorine ratio of 5:100. Reaction proceeds at room temperature for one hour and is then quenched with water. Tetrahydrofuran and naphthalene are vacuum-stripped from the quenched reagent for recycling. Reaction yields heat-transfer fluid containing < 1 mg/L PCBs. Remaining "pot residue" consists of non-halogenated polyphenyls, which can be burned, and sodium chloride. Not suitable for aqueous materials.

STATUS OF DEVELOPMENT AND USAGE – Goodyear is not pursuing commercial development of sodium naphthalide technology; technical data are public information. Commercialization of the process has been adapted by other companies. See also Acurex PCB Destruction Process (Entry No. 138) this section.

PERFORMANCE – Commercial-scale testing has shown that sodium naphthalide can successfully be used to reduce the PCB concentration in large amounts of heat transfer fluid from 130 mg/L to < 2 mg/L under an inert nitrogen atmosphere.

AVAILABILITY AND COMMERCIAL INFORMATION –

The Goodyear Tire and Rubber Company
Chemical Division
P.O. Box 9115-T
Akron, OH 44305
U.S.A.
Telephone (216) 796-3010

OTHER DATA –

Reagent Cost (12 September 1980)

	kg*	$/kg**	$/45 kg Oil
Sodium Metal	0.0498	0.64	0.0703
Heat-Transfer Oil	0.4987		
Naphthalene	0.3188	0.36	0.2530
Tetrahydrofuran	0.8856	0.86	1.6792
			2.0025

* Material cost per kilogram of heat-transfer fluid treated is @ $0.06.
** Unit cost will depend on quantities purchased.

Technique also used to treat other halogenated contaminants e.g., PBBs, DDT tetrachlorobenzodioxin.

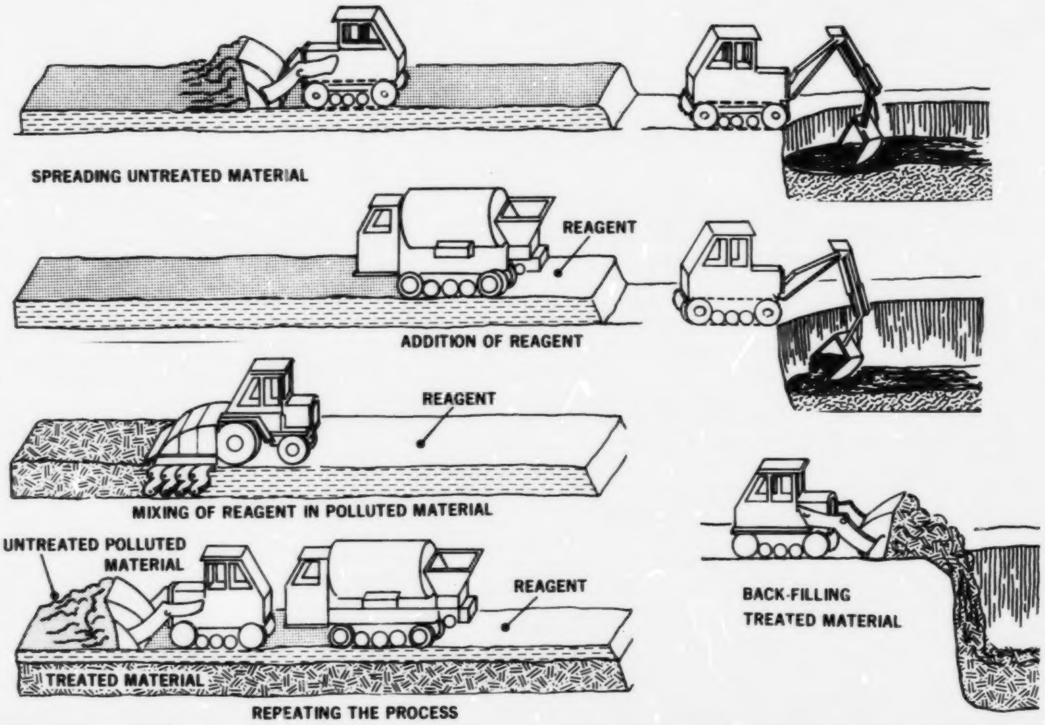
References: Man. Lit. M.M. Dillon Ltd., "Destruction Technologies for Polychlorinated Biphenyls (PCBs)", Report EPS 3-EC-83-1, Environment Canada, February, 1983 (July, 1983 reprint).

PRODUCT THE SOIL RECOVERY™ PROCESS **No. 148**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
		*	*			

DESCRIPTION – A process for converting hydrocarbon-containing hazardous wastes into hydrophobic, easily-compacted particles which can be used as environmentally stable landfill. The oil-containing waste can be treated directly on site.


SPREADING UNTREATED MATERIAL
REAGENT
ADDITION OF REAGENT
REAGENT
MIXING OF REAGENT IN POLLUTED MATERIAL
UNTREATED POLLUTED MATERIAL
REAGENT
TREATED MATERIAL
REPEATING THE PROCESS
BACK-FILLING TREATED MATERIAL

OPERATING PRINCIPLE – A waste material containing oil is reacted with quick-lime and a special calcium oxide-based reagent which forms small particles with large surface areas which absorb the oil. These small particles are water-repellent and easily compressed.

PHYSICAL SPECIFICATIONS – Not applicable. Sampling equipment, laboratory analyses, conventional excavating equipment, spreaders and a mobile mechanical mixer are involved.

OPERATING SPECIFICATIONS – Components and compounds present in an oil waste material are encapsulated and bonded in the product.

The oil in the treated product has low water solubility and remains chemically unchanged.

Can be conducted on waste spill on site by trucking the waste to an open space, spreading it out, and mixing in the reagents to form the finely divided product.

The product is inert and impervious to weather changes.

Reagents are specially adapted to the chemical composition of the oil waste.

Cost of process varies with the size and contents of the spill, although it is considered economical because the spill can be treated on site.

STATUS OF DEVELOPMENT AND USAGE – Commercial process.

It has been used extensively in Europe to treat oil-contaminated soil, acid sludges, acid residue from benzene refining, lignite tar and emulsion sludges.

Process used to treat 23 000 m^3 of hazardous chemical waste in Mercier, Quebec.

PERFORMANCE – Independent evaluation of process efficiency was not obtained.

AVAILABILITY AND COMMERCIAL INFORMATION –

Soil Recovery, Inc.
P.O. Box 2147
95 Madison Avenue
Morristown, NJ 07960
U.S.A.
Telephone (201) 540-0566
Telex 13-6325
Contact: Mr. J. Shofel

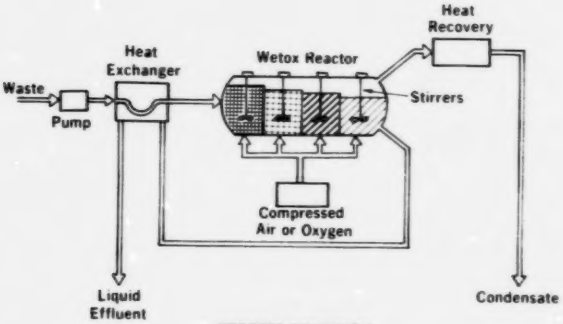
OTHER DATA – Patented process. A stationary plant using this process has been developed that can be adapted to areas generating waste at a regular rate.

PRODUCT ONTARIO RESEARCH FOUNDATION WETOX PROCESS **No. 149**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*					

DESCRIPTION – A system capable of oxidizing a wide variety of toxic, hazardous or obnoxious organic wastes from 2 to 20% in water. A typical installation includes a multi-compartmented horizontal autoclave, high-pressure liquid pump, air compressor, agitators, heat exchanger, coolers, vapour and liquid let-down systems, and auxiliary equipment.



PROCESS SCHEMATIC

OPERATING PRINCIPLE – The influent waste is heat-exchanged with the reacted liquid effluent and passes into the multi-compartmented reactor. Each inner compartment contains an agitator and air/oxygen supply. The waste cascades successively to each compartment where the organic content is oxidized primarily to carbon dioxide, water and ash, plus small amounts of organic acids e.g., acetic, formic. Nitrogenous compounds are reduced quantitatively to sulphate. Agitation greatly increases mass transfer of oxidant, resulting in efficient operation at modest temperatures and pressures (240 to 260°C and (3 to 6 MPa) (400 to 850 psi)). The vapour (steam) and liquid phases exit the reactor separately. The volume of effluent waste can be effectively reduced by up to 90% for chemical recovery (e.g., soluble metals) or post-treatment prior to ultimate disposal. The vapour products from the oxidation are automatically and thoroughly scrubbed, minimizing air and odour pollution.

PHYSICAL SPECIFICATIONS – None obtained.

OPERATING SPECIFICATIONS – Normal Wetox operation is accomplished at 230 to 260°C and 3 to 6 MPa (400 to 850 psi).

A high degree of destruction is obtainable for most organic wastes: autothermal operation is achieved with most organics in excess of 1.5% of the incoming stream.

Can process organic wastes from 2 to 20; can effectively destroy dilute toxic wastes, especially when such wastes cannot be or are too expensive to concentrate.

The process can effectively destroy hazardous, toxic or obnoxious materials difficult to treat safely by other methods.

STATUS OF DEVELOPMENT AND USAGE – The system is not available yet as a mobile unit suitable for the treatment of spilled hazardous materials.

PERFORMANCE – The following results were obtained after a 1-h reaction period:

Compound	Starting Concn. (g/L)	Reaction Temp. (°C)	% Starting Material Destroyed
Thiocyanate	9.6	250	>99.8
Pentachlorophenol*	11.7	240	>99.94
Phenol	4.4	232	>99.99
Diphenylamine	3.0	265	>99.99
Mercaptobenzothiazole	3.5	240	>99.99
Cyanide	Up to 75.0	250 to 275	>99.998

* in Na_2CO_3 solution, with 250 ppm CuO catalyst

AVAILABILITY AND COMMERCIAL INFORMATION –

Ontario Research Foundation
Sheridan Park Research Community
Mississauga, Ontario
Canada
L5K 1B3
Telephone (416) 822-4111
Contact: Mr. H. Robey

OTHER DATA – Information was supplied by the Ontario Research Foundation (ORF). Reports prepared by ORF on the Wetox Process are available upon request.

M.M. Dillon Ltd. reports that a mobile Wetox process housed in a truck was tested for PCB destruction by ORF who reported an efficiency of 50 to 70% with long batch times and temperatures above 250°C. "The work was abandoned as a result of unrelated local political problems." Michigan Technological University in Hougton, MI are co-developers of the process and have tested it on PCBs at higher temperatures with encouraging results.

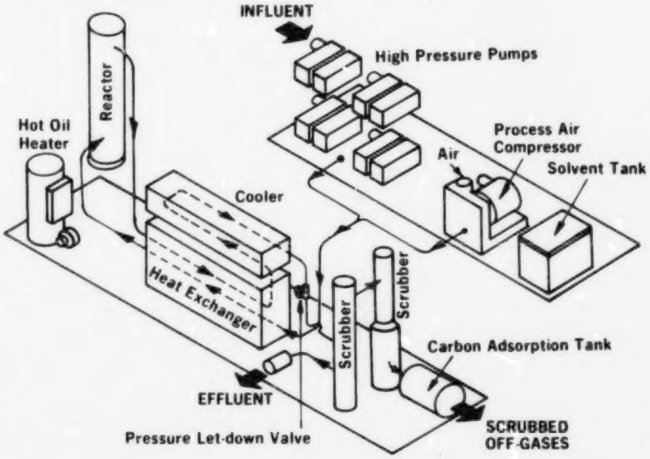
Reference: M.M. Dillon Ltd., "Destruction Technologies for Polychlorinated Biphenyls (PCBs)", Environment Canada, Report EPS 3-EC-83-1 (February, 1983) (July 1983 reprint).

PRODUCT ZIMPRO WET AIR OXIDATION PROCESS **No. 150**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – A mobile system which oxidizes hazardous materials in an aqueous environment. It consists of a high pressure pump, air compressor, heat exchanger, cooler reactor, scrubbers, carbon adsorption tank, and ancillary equipment.



OPERATING PRINCIPLE – The material to be treated is mixed with compressed air and pumped through a heat exchanger into the reactor. Organic matter in the wastewater is oxidized exothermically to carbon dioxide and water, and to ammonia in the case of nitrogenous chemicals such as nitriles or cyanides. The oxidized liquor is passed through the heat exchanger to heat the incoming wastewater, and then into a cooler. The liquor exits the cooler via a pressure let-down valve and enters the base of a two-stage scrubbing system which initially acts as a separator for the liquid and vapour phases. The liquid effluent is then pumped from the system (for further treatment if required), while the vapours pass through the two scrubbing towers. The design of the scrubbers can be tailored to the type of waste, and can include water for removal of ammonia and volatile, low molecular weight organics, or caustic soda for any residuals of hydrochloric acid. As a final precaution there is also the provision of a carbon adsorption chamber to avoid any carryover of hydrocarbons.

PHYSICAL SPECIFICATIONS –

Skid-mounted unit consists of:

Two platforms of equipment, approximately 2.4 x 10.7 m (8 x 35 ft) (width x length); and the reactor, approximately 10.7 x 1.0 m (35 x 3 ft) (length x diameter).

Two skids and reactor are delivered to spill site by three truck trailers and bolted to concrete pads.

Materials of construction:

316 L (84 U.S. gal) S.S., Carpenter-20, Incoloy/Inconel, Hasteloys, Titanium or other alloys as required.

Instrumentation: Electronic, small case.

Electrical Enclosures: NEMA I-A (Gasketed).

Utilities:

Power 180 kW (440 V, 3 phase, 60 Hz)
Fuel Oil: 0 to 22.7 L/h (6 U.S. gal/h)
Cooling Water: 3.2 to 4.4 L/s (0.8 to 1.2 U.S. gal/s)

Operating Labour: 4 mh/8 h shift (13 ft h/8 h shift)

OPERATING SPECIFICATIONS –

Maximum Flow Rate: 0.6 L/s (10 U.S. GPM) of wastewater containing 45 g COD/L.

Oxidation reaction occurs in an aqueous environment at temperatures between 232 to 315°C (450 to 600°F) and pressures between 103 to 207 bar (1500 to 3000 psig).

Conditions can be adjusted to modify degree of oxidation, such that the treated effluent may be suitable for discharge to a watercourse or may require further treatment by conventional biological methods.

Unit includes a solvent tank containing nitric acid which is used for cleaning the system.

STATUS OF DEVELOPMENT AND USAGE – Commercially available for treatment of phenols, cyanides, chlorinated hydrocarbons and other toxic compounds in industrial wastewaters.

PERFORMANCE –

The following laboratory results are reported by the manufacturer for one hour reaction times:

Compound	Starting Concentration (g/L)	% Starting Material Destroyed		
		320°C	275°C	275°C/ Cu^{++} catalyst
Acenaphthene	7.0	99.96	99.99	—
Acrolein	8.41	>99.96	>99.05	—
Acrylonitrile	8.06	99.91	99.00	99.50
2-Chlorophenol	12.41	99.86	94.96	99.88
2,4-Dimethylphenol	8.22	99.99	99.99	—
2,4-Dinitrotoluene	10.0	99.88	99.74	—
1,2-Diphenylhydrazine	5.0	99.98	99.98	—
4-Nitrophenol	10.0	99.96	99.60	—
Pentachlorophenol	5.0	99.88	81.96	97.30
Phenol	10.0	99.97	99.77	—

A skid-mounted Wet Air Oxidation unit was installed (1983) permanently at the toxic waste landfill site of Casmalia Resources Management in Santa Barbara County, CA.

Zimpro Wet Air Oxidation Performance at Casmalia Resource Landfill, Santa Barbara County, CA

Waste	Parameter	Feed	Effluent	% Removal
Acidic Distillate	COD, g/L	63.8	4.1	93.6
Spent Caustic	COD, g/L	108.1	11.6	89.3
	Phenols, mg/L	15 510	36	99.77
	Sulphide, mg/L	3 320	< 1	>99.97
Metal Plating	COD, g/L	97.0	5.3	94.5
	Total Cyanide, mg/L	33 000	2.4	99.99
Metal Plating	COD, g/L	73.3	2.1	97.1
	Total Cyanide, mg/L	34 000	1.7	99.99

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Zimpro Inc.
Military Road
Rothschild, WI 54474
U.S.A.
Telephone (715) 359-7211
Telex 29-0495
Contact: Industrial Sales Dept.

OTHER DATA – None

Cost (June, 1981):
316 Stainless Steel Construction: $1.1 million
Titanium Construction: $1.75 million

References: Manufacturers' Literature; "California Toxics to Wet Oxidation", in The Reactor Magazine, No. 49 (October, 1982).

5.4 Biodegradation

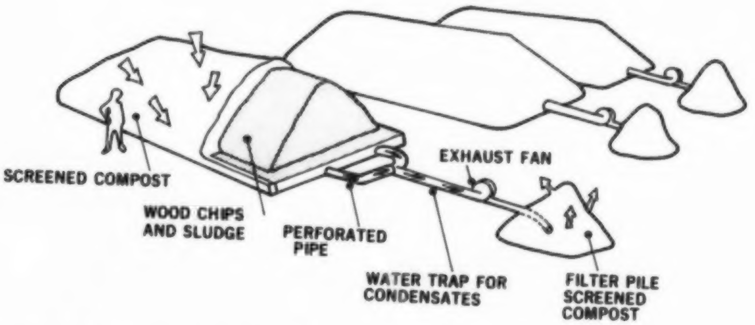
PRODUCT COMPOSTING AND LAND FARMING - GENERAL LISTING **No. 151**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*	*	*	*

Note: Applicable to liquids and solids mixed with soil and other solids.

DESCRIPTION – Composting is the biological degradation of organic materials to simple end products (CO_2, H_2O) under primarily aerobic conditions. The organic materials can be solids or liquids absorbed by solids. These are processed in a relatively dry environment compared to activated sludge treatment of wastewaters. Aerobic composting is carried out in enclosed systems, on land or in soil. The latter method is more commonly known as land farming, land cultivation or sludge farming. Decomposition of organic matter through land farming is generally slower than composting in controlled digesters (enclosed systems) or on land (windrow or forced aeration windrow).



OPERATING PRINCIPLE – A mass of organic solids is aerated by sequential mixing and/or forced aeration to enhance conditions for the growth of aerobic micro-organisms. Four types of composting systems exist to provide optimum conditions:

1) Enclosed Systems - digesters or basins equipped with agitators and aerators.

2) Windrows - long rows of organic solids spread on soil or on a concrete pad and sequentially mixed to aerate the organic matter.

3) Forced Aeration - primarily windrows with air blowers drawing air from the base of the organic mass through perforated pipes.

4) Land Farming - organic matter is cultivated into the upper layer of soil using conventional farm equipment or construction equipment.

Composting relies on long retention periods (3 to 6 months) to allow the micro-organisms to acclimatize to the waste and environment. Normally biodegradation begins through mesophilic organisms (optimum temperature: 20 to 40°C) and then is maintained at steady state through thermophilic organisms (optimum temperature: >40°C). (Temperatures rise in the organic mass due to the exothermic hydrolysis and oxidation reactions of biodegradation.) Fungi and facultative anaerobic micro-organisms (grow with or without the presence of oxygen) are also active if composting takes place in a soil media. Anaerobic (growth without oxygen) micro-organisms will begin to dominate the biodegradation process if the compost mass is not agitated or sufficiently aerated. Aerobic composting is preferred because it is faster and more effective and does not generate foul odours (e.g., sulphur compounds, methane) as occurs in anaerobic composting.

The micro-organisms can be either indigenous to the waste organics or introduced from other sources, such as activated sludge or mutant bacteria (see Entry No. 152).

PHYSICAL SPECIFICATIONS – The equipment required to operate a composting system varies from process to process. However, some major components include:

Windrow turning machines (front-end loaders and farm tractors with modified cultivating equipment are also employed).
Air blowers.
Perforated pipe (PVC, ABS) for aeration.
Conveyors.
Tarpaulins (to cover windrows during winter or adverse weather conditions).
Inventories of: - nutrients (N, P fertilizers);
 - pH adjustment chemicals.
Pumps and equipment to treat the leachate and runoff.

OPERATING SPECIFICATIONS – Aerobic composting is the most efficient method of composting. Generally:

Moisture content of the organic matter should range from 40 to 60% on a wet weight basis. Below 40%, enzymatic action is impeded and above 60% the free pore space is reduced and improper aeration occurs.

Carbon-to-nitrogen ratio should be maintained between 20 and 30 (weight basis). Ratios in excess of 30 will slow the reaction and below 20 nitrogen losses are high.

Oxygen levels should be maintained between 5 and 15%. Levels below 5% can result in anaerobic pockets, while levels above 15% will affect the temperature regime. (Excess mixing or aeration can cool down windrows and slow microbiological activity.)

Windrow Composting

A typical windrow composting operation would operate as follows (2):

1. 3 to 4 weeks: Spread the media and organisms into flat beds (2-in thick). Dose with waste; lace with nutrients (nitrate) and alkalines (lime and calcium carbonate).

2. 7 to 10 days: Pile media, organism and waste mass into compost windrow forms (4-in high).

3. Repeat flattening of beds for aeration.

4. Repeat waste dosing, nutrient addition and pH adjustment.

5. Repeat windrow piling.

Location of windrow piles is alternated so that biochemical bed bottoms do not get mucky and impervious. An aerated pervious bed bottom allows continuous leachate drainage.

In 1975, the U.S. Department of Agriculture (USDA) developed the forced aeration system for composting sewage sludge. The major advantages of this method for handling wastes are:

1. The microbial decomposition of sludge during composting alleviates malodours and produces a stable, humus-like, organic material.

2. Heat produced during composting effectively destroys human pathogens.

3. The product can be stored conveniently, and spread easily and uniformly on land. Sludge, on the other hand, is difficult to handle and produces odours when stored.

4. Composting produces an organic resource that can be used beneficially on land as a source of plant micro- and macronutrients, and as a soil conditioner.

5. Low capital investment and low energy requirements.

Filter cake sewage sludge (approximately 22% solids) was mixed with a bulking material and then composted in a stationary aerated pile for 21 days. Bulking materials added were: woodchips, shredded paper, paper briquets, leaves, peanut hulls and automobile salvage fabrics.

Sludge at this moisture content (78% water) will not compost aerobically alone because sufficient air cannot penetrate the biomass, either by diffusion or forced aeration. The bulking material provides the necessary texture, structure and porosity for aeration lowers the moisture content of the biomass to about 50 to 60% and provides an additional carbon source for micro-organisms to ensure rapid composting.

The ratio of the bulking material to sludge varies with the type of material and its physical characteristics, and the moisture content of the sludge. For composting sludge with woodchips, two volumes of woodchips are mixed with one volume of sludge (about 1:1 on a weight basis). This produces the necessary absorbency to lower the moisture content from 78% to about 60%. Mixing can be achieved with various types of equipment, the simplest being a front-end loader.

After mixing, the aerated pile was constructed of a loop to 10-cm (4 in dia.) perforated plastic pipe laid on the surface and covered with 30 cm (11 in) of woodchips or unscreened compost. The sludge-woodchip mixture was placed in a pile on the prepared base and blanketed with a 30-cm (11 in) layer of screened compost for insulation and odour control. Fifty tons of wet sludge produces a pile with a triangular cross-section, and approximate dimensions of 16 x 7 x 2.5 m (52.5 x 23 x 8 ft) (length x width x height). The loop of perforated pipe was connected with solid pipe to a 0.33-hp blower controlled by a timer. Aerobic composting conditions were maintained by drawing air through the pile, and the effluent airstream was conducted into a small pile of screened, cured compost, where odorous gases were adsorbed. The blower operated intermittently to provide oxygen levels between 5 and 15% during the composting period.

Land Farming

In land farming, the principal groups of micro-organisms present in surface soils are bacteria, actinomycetes, fungi, algae and protozoa. In addition, other micro- and macrofauna are often present, such as nematodes and insects. The bacteria are the most numerous and biochemically active group of organisms, especially at low oxygen levels.

In general, conditions favourable for plant growth are also favourable for the activity of soil micro-organisms. Environmental factors influencing plant growth and range of values conducive to growth are (2):

- soil pH - range of 4-10; pH 7 is generally optimal.
- air temperature - varies with type of organism; 30 to 40°C (86 to 104°F) is optimal.
- soil moisture content - a certain minimum water content is required, generally in the range of 30 to 90% of the water-holding capacity of the soil.
- nutrients - all nutrient elements required for the growth of higher plants are needed for microbial growth. Adequate nutrients are present in most fertile soils but additional nitrogen must be added if a highly carbonaceous waste (C/N ratio >35) is applied.

The suitability of a specific industrial waste for land cultivation depends on many characteristics, including pH; biochemical oxygen demand (BOD); odour; concentrations of chemical elements (e.g., heavy metals and sodium), soluble salts and hazardous chemicals; bulk densities of waste solids; flammability; and volatility.

Industrial waste is normally considered suitable for land cultivation if it complies with:

1. the organic portion biologically decomposes at a reasonable rate;

2. it does not contain material at concentrations toxic to soil micro-organisms, plants or animals, and there must be reasonable assurance that long-term toxic effects resulting from accumulation through adsorption or ion exchange can either be prevented or mitigated;

3. it does not contain substances in sufficient concentration to adversely affect the quality of the groundwater; and

4. it does not contain substances in sufficient concentration to adversely affect soil structure, especially the soil infiltration, percolation and aeration characteristics.

STATUS OF DEVELOPMENT AND USAGE – Historically, composting involved leaving organic matter in piles or holes for decomposition prior to reuse as a soil supplement for agricultural lands. It became a systematic process for dealing with vegetable matter and animal manure in India and Italy in the 1920's. Between 1951 and 1969, eighteen composting plants were built in the United States, but most were closed due to lack of viable markets for soil conditioning products. Composting has been more successful in Europe, the Middle East and Asia where additional organic matter for the soil is needed. In Canada, the Ontario Ministry of the Environment has been investigating the commercial viability of compost produced from industrial wastes at a full-scale, experimental resource recovery facility (3).

Land farming has been employed by petroleum companies and some private waste disposal firms for the disposal of oily wastes.

At present, composting has had limited acceptance by industry because of its vulnerability to climatic changes, labour requirements and slow reaction. However, the low capital investment and in-situ application possibilities make composting a viable countermeasure for hazardous material spills.

In the United States cautions about biological countermeasures are expressed in Annex X of the U.S. EPA National Oil and Hazardous Substances Pollution Contingency Plan. The plan states that biological countermeasures:

> "may be used only when such use is the most desirable technique for removing oils or hazardous substances and only after obtaining approval from the appropriate state and local public health and water pollution control officials. Biological agents may be used only when a listing of organisms or other ingredients contained in the agent is provided to EPA in sufficient time for review before its use."

PERFORMANCE – Some of the more potentially biodegradable industrial wastes are (1):

1. organic chemicals and solvents;
    - phenol,
    - xylol,
    - toluene,
    - ketones, alcohols,

2. oils, fats and waxes;
    - bunker oil,
    - petroleum acid pitch,
    - waste oil and diesel fuel,

3. wood and paper products;
    - papermill sludge,
    - paper wastes,
    - wood wastes - bark shavings,

4. agricultural and pharmaceutical wastes;
    - molasses silage,
    - mycellial wastes,
    - apple, grape and other fruit pomace,
    - food wastes.

Rose and Mercer investigated the composting of the pesticides DDT, Diazinon and Parathion (phospharothioate insecticides). Within ten days the Diazinon concentration was reduced approximately 50% and in 42 days the initial concentration of 3.3 ppm was reduced to less than 0.002 ppm. The concentration of Parathion was reduced by 50% in 12 days of composting. Degradation of pp-DDT was considerably slower. Fifty days of composting were required to reduce the level of DDT from 2.2 to 0.8 ppm. It was interesting to note that DDD and DDE, which are normally produced by DDT degradation in soils, were not detected in the composted material. This aspect is extremely important since breakdown products such as DDD and DDE may be as environmentally undesirable as the parent compound.

Osmon and Andrews were able to degrade large quantities (5 to 10%) of TNT in a relatively short time to zero or acceptable levels. No breakdown products or compounds of environmental concern were found.

Halogenated aromatic hydrocarbons (e.g., PCBs) have been found the most resistant organics to significant degradation by typical microbial populations in soils (2). Isbister et al. (4) found aerobic composting, using alfalfa hay, Purina Sweetena Horsefeed and Landland soil as the base, was more efficient in decreasing PCB concentrations (Aroclor 1242) than anaerobic composting, but the percent reductions, even after four weeks, were not acceptable compared to other PCB-destruction methods (e.g., incineration).

Degradation of PCBs in Soil: Lab Results (4) (% degraded)

After	Aerobic	Anaerobic
2 weeks	41.6 to 48.1 %	18.4 to 28.0 %
4 weeks	55.7 to 67.6 %	27.9 to 46.9 %

AVAILABILITY AND COMMERCIAL INFORMATION – Information regarding commercial composting systems was not readily available. However, references (see below) cite the following research firms as investigating the feasibility of composting as a countermeasure to hazardous material spills:

Atlantic Research Corporation
Alexandria, VA

Energy Resources Company, Inc.
Cambridge, MA

Polybac Corp. (see Entry No. 152) markets mutant bacteria for biodegradation of hydrocarbons, surfactants and refractory organics.

OTHER DATA –

References: Toxic and Hazardous Waste Disposal, "Volume 4: New and Promising Ultimate Disposal Options", (Robert B. Pojasek, ed). Ann Arbor Science Publishers, Inc.: Ann Arbor, MI (1980).

Kiang, Yen-Hsiung and Amir A. Metry, Hazardous Waste Processing Technology, Ann Arbor Science Publishers, Inc.: Ann Arbor, MI (1982).

Work experience at the Ontario Centre for Resource Recovery, Downsview, Ontario; Contact:

Waste Management Branch
Ontario Ministry of the Environment
135 St. Clair Avenue West, 2nd Floor
Toronto, Ontario
M4V 1P5
Telephone (416) 965-6191

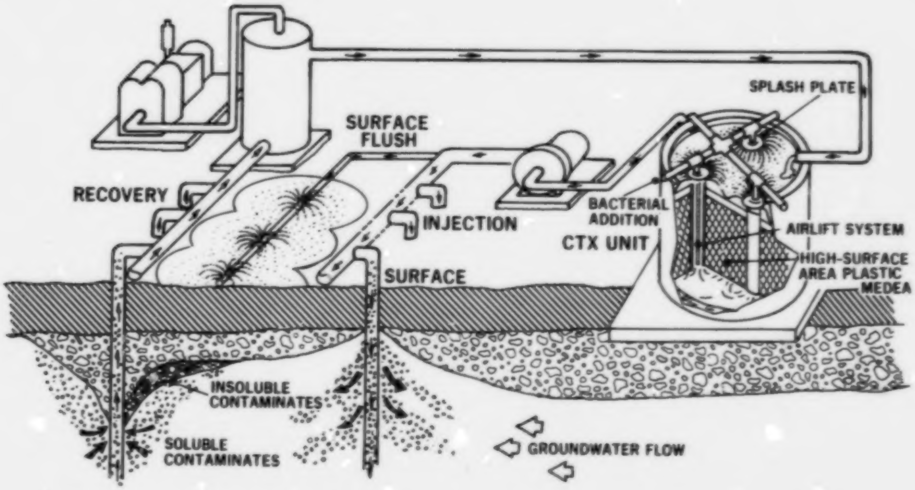
Isbister, J.D. et al., "Composting for Degradation of PCBs in Soil", 1984 Hazardous Materials Spills Conference Proceedings, Nashville, TN, pp 105-109 (April 9-12, 1984).

PRODUCT POLYBAC, MUTANT BACTERIAL HYDROCARBON DEGRADER No. 152

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*			

DESCRIPTION – A bacteria complex capable of degrading hazardous materials, spilled on land or in water, by biochemical oxidation. It consists of mutant, adapted micro-organisms and biochemical accelerators.



OPERATING PRINCIPLE – Hydrobac, Phenobac, and Petrobac are specially adapted, mutant bacteria strains which have an enhanced capacity for the degradation of specific types of organic chemicals. Hydrobac micro-organisms can biologically degrade refinery/petrochemical waste waters or spills containing a large number of chemicals in small varying concentrations; Phenobac has a specific activity against surfactants and synthetic detergents; and Petrobac is used to degrade spills of refactory organic materials in soil or salt water. The dehydrated bacteria are activated with water and placed into the hazardous organic spill to biochemically degrade the hydrocarbons present.

PHYSICAL SPECIFICATIONS –

Form: Free-flowing powder
Colour: Buff to brown
Specific Gravity: 0.5 to 0.7
Storage: 11.3 kg (25 lb) or 45.3 kg (100 lb) containers. Dry place at room temperature not exceeding 43°C (108°F). Do not freeze.

OPERATING SPECIFICATIONS – Hydrobac and Phenobac degraders are applied to fresh-water and land spills. Petrobac can be used in salt water and on land.

Degradation rate depends on: chemicals involved, temperature and soil conditions.

Can be applied at a rate of about 56 to 112 kg/ha (50 to 100 lb/acre). Application rate varies with varying characteristics of hazardous materials. Typical rates for Hydrobac, Phenobac, and Petrobac range from $33 to 66 U.S./kg ($15 to 30 U.S./lb).

In-situ Spill-site Decontamination-Engineering Considerations:

1) Biodegradability of the material;
2) Solubility of the material;
3) Quantity of the material spilled;
4) Environmental contamination and site geology;
5) Nutrient requirement;
6) Oxygen requirement;
7) Temperature effects;
8) Moisture effects; and
9) pH effects.

Activated with water (1:10) to form a homogeneous suspension, then sprayed or sprinkled over the contaminated area.

Polybac biodegradable emulsifier (Polybac E) can be added to the degraders to enhance the interfacial contact between the micro-organisms and hazardous materials.

Polybac biodegradable nutrients (Polybac N) can be added to the degraders to supply a balanced mixture of nitrogen and phosphorus to promote micro-biological growth and speed up degradation.

Optimum Temperature Range: 10°C to 40°C.

For soil and sand applications, it is recommended that the area be plowed to provide greater surface area for oxygen transfer and micro-organism contact. Ensure the area is moistened every 48 hours.

Hydrobac, Phenobac and Petrobac can be used to clean up spills of such bioresistant compounds as orthochlorophenol, dioxin, diesel fuel, ethyl acrylate, and acrylonitrile.

Phenobac and Hydrobac can degrade benzenes, phenols, cresols, naphthalenes, amines, alcohols, synthetic detergents, petroleum (crude and processed), kerosene, cyanides (diluted) and other bioresistant wastes from refineries and associated chemical operations.

Petrobac mutant bacteria are capable of converting aromatic, asphaltic, paraffinic and naphthenic crude oils to carbon dioxide, water and microbial protoplasm. Intermediate products from crude oil processing such as organic acids, alcohols, aldehydes, ketones, esters and other chemical intermediates can also be degraded.

Polybac degrader handling precautions:

User must wear surgical or industrial nose and mouth mask to avoid inhalation of bacteria dust.

Must remain completely dry until water activation just prior use.

Store in container with a tightly closed plastic liner.

STATUS OF DEVELOPMENT AND USAGE — Polybac mutant bacteria are commercially available and have been used in various cleanup operations of organic chemical spills, including tank farm releases and railroad derailments.

PERFORMANCE — The effectiveness of parent and mutant bacteria strains in degrading various hazardous materials is documented in the following figure:

- About 15 100 m^3 (4 million U.S. gal) of wastewater in a 0.8 ha (2 acres) bearing plant lagoon were cleansed of 99% of waste oil content by treatment with Petrobac and Phenobac over consecutive fall and summer seasons. The treated lagoon water was pumped into the municipal sewer system at the end of the treatment period. Total project cost - including chemicals, bacterial additives, engineering, and analytical work - was approximately $80 000 (U.S.).
- An area of 15 800 m^2 (170 000 ft^2) of soil of a bulk oil tank farm was saturated to a depth of 3.8 cm (1.5 in) after initial vacuum truck pick-up of 800 m^3 (5000 barrels) sweet crude spill. The soil was tilled and inoculated with approximately 18 kg (40 lb) of Hydrobac mutant bacteria. Soil samples showed a 66% reduction in oil content from August 5 to September 10. The soil was supporting vegetation at the end of the second month. The project cost was approximately $16 000 U.S. versus $75 000 U.S. estimated to remove and landfill the soil.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Polybac Corporation
954 Marcon Blvd.
Allentown, PA 18103
U.S.A.
Telephone (215) 264-8740
Contact: Curtis S. McDowell,
Technical Service Manager.

Canadian Liaison Office:

Polybac Corporation
11440 Crockett Rd.
P.O. Box 330
Roscoe, IL 61073
U.S.A.

OTHER DATA – Other Polybac Products:

Name:	Degrades:
Formula 90	Grease and Fat
Lignobac	Pulping and Paper Making Waste
Fibrobac	Fibrous Solids
Oleobac	Trapped Grease and Fats
Polybac	Sewage and Food Wastes
Filabac	Filamentous Growth

Polybac also provides emergency and remedial cleanup of hazardous organic materials of accidental spill sites, impoundments, lagoons, landfill leachates, abandoned dump sites, and contaminated groundwater arising from such sources. The processes used are Polytreat, Polysoil, and Polydetox, site-specific unit operations.

Polytreat: Treatment of impounded, water-borne wastes, including suspendable sediments, resulting in environmentally acceptable effluent for discharge to a municipal sewer or wastewater treatment plant.

Polysoil: Treatment of soil or sand accessible from the surface after gross removal of spilled or dumped waste materials.

Polydetox: Decontamination of soils or strata not accessible from the surface by aqueous leaching and collection/treatment of the leachate at the surface (see attached figure of Polydetox process).

Biological products presently accepted as hazardous material countermeasure by the U.S. Environmental Protection Agency under Annex X of the National Oil and Hazardous Substances Pollution Contingency Plan include:

NOSCUM	Natural Hydrocarbon Elimination Company 5400 Memorial Drive Houston, TX 77007	Petrobac R Phenobac R Hydrobac	Polybac Corporation 1215 South Cedar Crest Boulevard Allentown, PA 18103
Petrodeg 100 Petrodeg 200	Bioteknika International, Inc. 7835 Greeley Boulevard Springfield, VA 22152		

References: Bennett, G.F., et al., Hazardous Materials Spills Handbook, McGraw-Hill Book Company, New York (1982).

Manufacturer's Literature.

Mr. E. Nyer, personal communication, Polybac Corp. (June 24, 25, 1981).

Walton, G.C. and D. Dobbs, Biodegradation of Hazardous Materials, O.H. Materials Co., Findlay, OH.

Krupa, M.J., Polybac Corp., "Biological Methods for the Detoxification of Hazardous Organic Materials", Coastal and Off-shore Oil Pollution Conference (September 10, 11, 12, 1980).

Thibault, G.T., "Biological Detoxification of Hazardous Organic Chemical Spills", 1979 Annual Conference on Oil and Hazardous Materials Spills (December 3-5, 1979).

"Mutant Bacteria Clean Up Waste Oil", American Machinist (July, 1981).

"Mutant Bacteria Decontaminates Spilled Crude Oil Site", Chemical Processing (December, 1982).

6 ANCILLARY EQUIPMENT

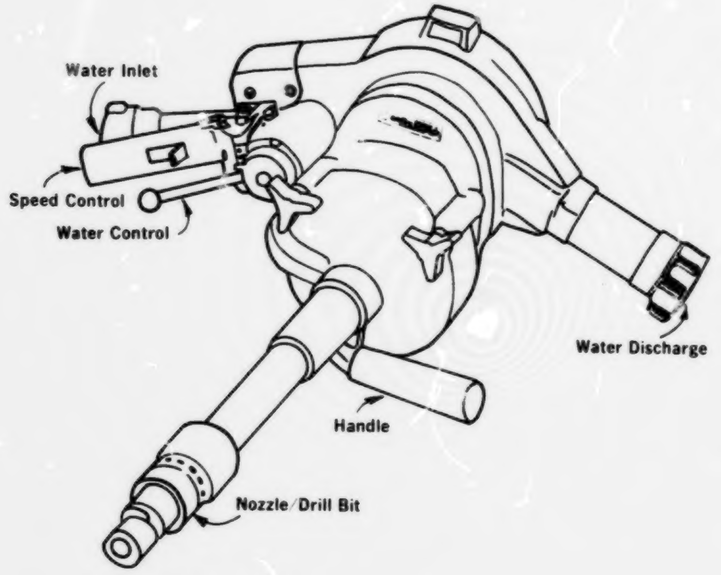
PRODUCT AMFIRE WATERDRILL **No. 153**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*	*	*	*

Note: Applicable to containers or structures holding liquids or solids.

DESCRIPTION – A lightweight, water-powered drill and extinguisher for penetrating masonry, wood and metals.



OPERATING PRINCIPLE – A pressurized water source is used to power a water turbine. Water can be sprayed through the tip of the cutting bits, allowing the drill to function as the nozzle of a fire hose.

PHYSICAL SPECIFICATIONS – Housing Construction: Cast aluminum with insulating dielectric coating. Weight: 8.2 kg (18 lb). Fittings: Standard 38 mm (1.5 in) fire hose coupling, inlet and outlet.

Description	Accessories: Model No.
Masonry Core Bits	
76 mm (3 in)	Model 3011-3
102 mm (4 in)	Model 3011-4
152 mm (6 in)	Model 3011-6
Wood Bits	
76 mm (3 in)	Model WB-3
102 mm (4 in)	Model WB-4
152 mm (6 in)	Model WB-6

A standard Amfire Waterdrill Kit contains:
- Amfire Waterdrill
- Heavy Gauge Aluminum Carrying Case
- 3" Diamond Core Bit
- 3" Wood Bit
- 3" Metal Hole Saw
- 18" Extension
- Nozzle
- One Pair Safety Goggles
- 5' length Exhaust Hose w/coupling

Description	Accessories: Model No.
Metal Bits	
76 mm (3 in)	Model HS-3
102 mm (4 in)	Model HS-4
152 mm (6 in)	Model HS-6
Exhaust Hose	
5 ft (1.5 m) Exhaust Hose w/couplings	Model EH-5C
Carrying Case	
Heavy Gauge Aluminum 305 x 305 x 610 mm (12 x 12 x 24 in)	Model CC-101
Extensions	
457 mm (18 in) Extension w/adapter	Model EX-18A
Goggles	
1 Pair Safety Goggles	Model GMS

OPERATING SPECIFICATIONS –

Operating Pressure at Pump Discharge: 1034 to 1723 kPa (150 to 250 psi)
Water powering the drill can be diverted through a nozzle at the tip of the cutting bit.
Uses salt or freshwater.

STATUS OF DEVELOPMENT AND USAGE – Used widely by firefighters for rapidly introducing water behind walls of masonry, wood or metal. Drill holes can be used to introduce agents such as foam, CO_2 or dry chemicals into truck trailers, box cars, aircraft hulls, mobile homes or ship bulkheads.

PERFORMANCE –

Barrier	Penetration Time(s)
20.3 cm (8 in) Railroad Tie	40
20.3 cm (8 in) Solid Concrete Wall	150
20.3 cm (8 in) Concrete Block	45
Formed Metal Roof (Panel)	10
Asphalt Roof	5
Armour Plate (76 cm (3 in) diameter)	600

No data were obtained regarding the sparking nature of the cutting bits or the safety of the operation of the drill in a hazardous material environment.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Amfire Industries Incorporated
P.O. Box 24657
Tampa, FA 33623
U.S.A.
Telephone (813) 884-8424

OTHER DATA – Operation of the Amfire Waterdrill is taught to firefighters at Texas A and M University.

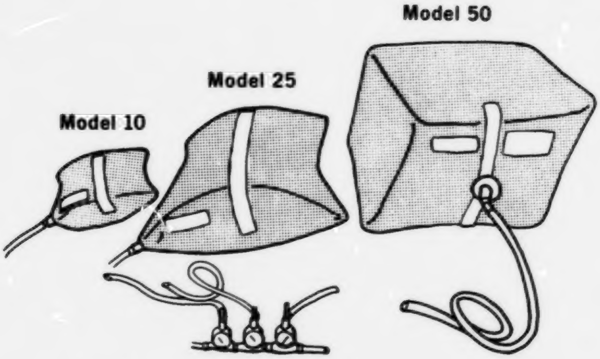
PRODUCT LAMPE-LIFTER AIR CUSHIONS **No. 154**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
*	*	*	*	*	*	*

Directly applicable to container not material.

DESCRIPTION – Low and high pressure flexible cushions in flat and sidewall models designed for lifting vehicles during their removal following overturning or other accident. They can be used to facilitate the quick rescue of people, the cleanup of spilled materials, and certain more routine maintenance and repair work on heavy equipment.



OPERATING PRINCIPLE – The air cushion is placed under the object to be displaced and inflated through a pressure reducer by an air compressor or other appropriate source of air thereby raising it.

PHYSICAL SPECIFICATIONS – All air cushions are fabricated from Kevlar and coated with Neoprene.

STOCK ITEMS

	Low Pressure			High Pressure
Model	10	25	50	10-400
Dimensions - empty cm	71 x 51 x 1.3	122 x 81 x 1.3	119 x 84 x 3	76 x 69 x 3
(in)	(28 x 20 x 0.5)	(48 x 32 x 0.5)	(47 x 33 x 1)	(30 x 27 x 1)
Weight kg	3.6	9.5	6.8	9.1
(lb)	(8)	(21)	(15)	(20)

NON-STOCK ITEMS

These are made to order only. They are available in standard models.

Model	1-250	1-500	1-1000	0.4-800
Dimensions - empty cm	152 x 152 x 6.4	335 x 152 x 2.5	335 x 320 x 1.9	396 x 351 x 10
(in)	(60 x 60 x 2.5)	(132 x 60 x 0.9)	(132 x 126 x 0.7)	(156 x 138 x 4)
Weight kg	50	41	77	227
(lb)	(110)	(90)	(169)	(500)
Style	sidewall	flat	flat	sidewall

Kits are also available consisting of models 10, 25 and 50 or two model 50s, etc. The three-model kit weighs 3.2 kg (7 lb) and is packaged in a carrying bag. It consists of three cushions, safety fittings and filling hoses, one pressure reducer, wrench, repair kit and operating manual, and two lash ropes. Other accessories can also be purchased including an air distributor and railway roller cart.

OPERATING SPECIFICATIONS –

STOCK ITEMS

Model	10	25	50	10-400
Maximum Lifting Force kg (lb)	2 722 (6 000)	8 165 (18 000)	7 258 (16 000)	38 102 (84 000)
Maximum Lifting Height cm (in)	30.5 (12)	50.8 (20)	78.7 (31)	35.6 (14)
Working Pressure (kPa) (psi)	103 (15)	103 (15)	103 (15)	1 000 (145)
Bursting Pressure (kPa) (psi)	690 (100)	400 (58)	400 (58)	4 000 (580)

NON-STOCK ITEMS

Model	1-250	1-500	1-1000	0.4-800
Maximum Lifting Force kg (lb)	34 474 (76 000)	49 896 (110 000)	99 792 (220 000)	79 833 (176 000)
Maximum Lifting Height cm (in)	198 (78)	91 (36)	196 (77)	450 (177)
Working Pressure (kPa) (psi)	103 (15)	103 (15)	103 (15)	41 (6)
Bursting Pressure (kPa) (psi)	359 (52)	359 (52)	359 (52)	152 (22)

Materials compatibility should be verified for application to specific spill incidents where contact with the released substance is probable.

STATUS OF DEVELOPMENT AND USAGE – Commercial product conceived for lifting heavy objects. Documentation of use during spill response was not obtained although an ancillary role to cleanup for this device is anticipated via-à-vis other containment, recovery and more direct treatment systems.

PERFORMANCE – Documentation of evaluation was not obtained.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:	Distributor:
Zumro Inc. 6003 Cassowary Lane New Bern, NC 28560 U.S.A. Telephone (919) 637-3561 Telex 704916	Code 4 Rescue 22 Strathern Avenue Block B, Unit 7 Brampton, Ontario L6T 4L8 Telephone (416) 791-6788

OTHER DATA – Lateral stability when using the flat Lampe-Lifter cushions is claimed to be very good and these can be applied under slanting surfaces. Lateral stability is more limited with the sidewall models so that wheels have to be blocked or the cushions used in multiples.

Zumro Inc. also manufactures Lampe sealing cushions for closing drains and pipes.

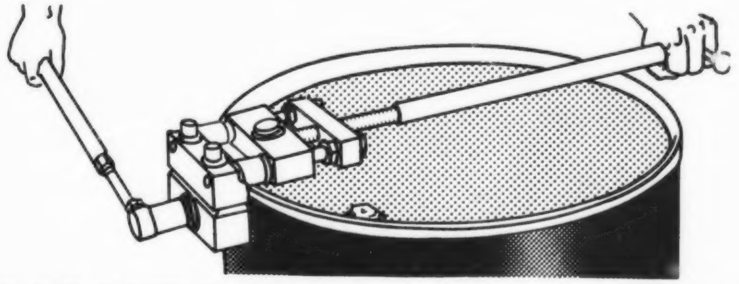
PRODUCT MANUAL DRUM DEHEADER **No. 155**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*	*	*	*

Note: This tool is designed for metal drums containing liquids or solids.

DESCRIPTION – Light, portable round blade cutting tool for removing the tops of metal drums.



OPERATING PRINCIPLE – Leaves a "hands safe" edge by cutting (like a pipe cutting tool) the inside edge of the top rim of a drum so that the head cannot be used as a cover.

PHYSICAL SPECIFICATIONS –

Weighs 9.1 kg (20 lb)
All-steel construction.
Complete with ratchet handle and detailed operating instructions.
Round blade cutting tool (spares available).

OPERATING SPECIFICATIONS –

Opens 76 to 208 L (20 to 55 U.S. gal) drums (16 to 18 gauge) and down to 51 cm (2 in) in diameter.

Removes head of a 208 L (55 U.S. gal) drum with approximately three passes.

Can open six drums in less than one hour, according to manufacturer.

STATUS OF DEVELOPMENT AND USAGE – Commercially available and widely used.

PERFORMANCE – Non-sparking performance is not specified, but this deheader is considered safe for drums containing hazardous materials because of its operation (similar to a domestic can opener).

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Wizard Drum Tools
1263 North 70th St.
Milwaukee, WI 53213
U.S.A.
Telephone (414) 476-7717
TWX 910-262-1189

Distributor:

BASCO
Barrel Accessories & Supply Co.
4647 West 47th St.
U.S.A.
Telephone (312) 767-8100 or
1-800-621-0621

Consult Fraser's Canadian Trade Directory for a complete listing of drum accessories dealers in Canada.

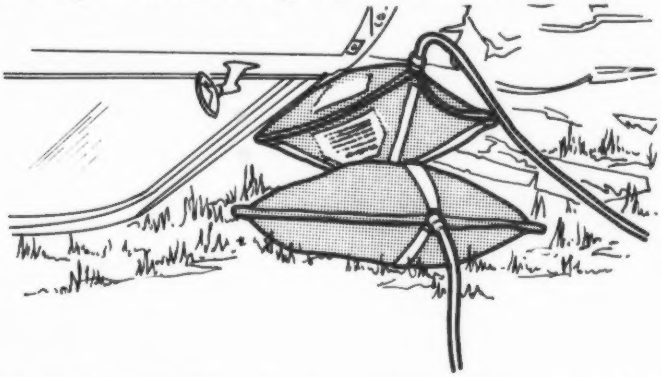
PRODUCT MAXIFORCE LIFTING BAGS **No. 156**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
*	*	*	*	*	*	*

Note: For lifting containers on land which may contain gases, liquids or solids.

DESCRIPTION – Maxiforce is an air bag constructed of neoprene and woven steel wire reinforcement, which, when inflated with air (or water), has the power to lift, move or shift weights up to 66 700 kg (146 000 lb). Two bags can be stacked to give up to 100 cm (40 in) of lift.



OPERATING PRINCIPLE – The bag can be inflated by many air sources, including back pack or scuba air cylinders, truck air brake systems, compressors, or even a foot pump. Inflation to the operating pressure of 6 to 8 bar (87 to 118 psi) is controlled by a safety control valve. Less than 2.5 cm (1 in) of space is required for insertion.

PHYSICAL SPECIFICATIONS –

Type			P8	P12	P16	P21	P24L	P30	P51
Size	Length	inches	15	21	20	24	42	28	36
		(mm)	(381)	(533)	(508)	(609)	(1066)	(711)	(914)
	Width	inches	15	15	20	24	15	28	36
		(mm)	(381)	(381)	(508)	(609)	(381)	(741)	(914)
	Thickness	inches	.7	.7	.7	.7	.7	.7	.7
		(mm)	(17.8)	(17.8)	(17.8)	(17.8)	(17.8)	(17.8)	(17.8)
Weight (approx):		lb	9.5	14	20.1	29.7	28.7	42.7	73.2
		(kg)	(4.3)	(6.3)	(9.1)	(13.5)	(13)	(19.4)	(33.3)

Material	Neoprene
No. of Steel Reinforcing Layers each side	3
Replaceable Connector	yes
Molded Non-slip Surface	yes
One-Inch Wide Bright Yellow "X" Molded Into Both Sides	yes

Lifting bags are available separately or in four factory designed systems. Each system includes a pressure-reducing valve, dual safety relief and control valves, two 4.5 m (15 ft) lengths of pressure hose, and an operation manual. The bags included in each system are:

Part No. of Factory Designed Systems

Type	890122	890112	890102	890103
P8	X	X	X	
P12	X	X	X	X
P16	X	X	X	
P21	X	X		X
P24L	X	X		
P30	X			
P51	X			

OPERATING SPECIFICATIONS –

Type		P8	P12	P16	P21	P24L	P30	P51
Part Number		890151	890156	890161	890166	890171	890181	890190
* Lifting Capacity at 87 psi (6 bar)	tons	8.8	12.5	16.0	23.4	25.5	32.2	54.0
	kg	7974	11343	14578	21285	23135	29257	48998
118 psi (8 bar)	tons	12.0	17.0	21.8	31.8	34.7	43.8	73.4
	kg	10845	15426	19826	28947	31463	39789	66637
* Lifting Height	inches	8.2	9.2	11.1	13.1	9.8	15.5	20.0
	(mm)	(208)	(233)	(282)	(333)	(249)	(394)	(508)
Maximum Working Pressure	psi	118	118	118	118	118	118	118
	(bar)	(8)	(8)	(8)	(8)	(8)	(8)	(8)
Test Pressure	psi	236	236	236	236	236	236	236
	(bar)	(16)	(16)	(16)	(16)	(16)	(16)	(16)
Bursting Pressure Minimum	psi	700	700	700	600	600	475	475
	(bar)	(47.6)	(47.6)	(47.6)	(40.8)	(40.8)	(32.3)	(32.3)
Air requirement at 87 psi (6 bar)	ft^3	2.3	3.8	5.7	10.7	9.1	16.8	36.4
	(L)	(65)	(107)	(161)	(303)	(257)	(475)	(1030)
118 psi (8 bar)	ft^3	3.0	4.9	7.3	13.8	11.7	21.6	47.0
	(L)	(84)	(138)	(208)	(390)	(332)	(613)	(1329)
Inflation Time	s	3 4	7	11	12	28	53	
Short-Term Temp. Range	°F				-75 to +220			
	°C				-60 to +105			
Continuous Duty Temp. Range	°F				-40 to +150			
	°C				-40 to +65			

* Lifting Capacity and Height will vary according to air pressure and bag contact area.

STATUS OF DEVELOPMENT AND USAGE – Commercially available for rescue applications on highways, railways, or in industrial plants.

PERFORMANCE –

Large concrete truck was raised high enough to free an automobile rammed underneath.

P16 bag did not puncture while holding a 11 363 kg (25 000 lb) concrete block for one half hour and resting on two meat cleavers.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Paratech Incorporated
1025 Lambrecht Road
Frankfort, IL 60423
U.S.A.
Telephone (815) 469-3911
Telex 723-445

Canadian Distributor:

Wilson & Cousins
6 Baker Road
Brampton, Ontario
L6T 4E3
Telephone (416) 793-3500
Telex: 06-97568

OTHER DATA – None obtained.

Reference: Maxiforce brochure, Paratech Incorporated, No. 10M (September, 1982).

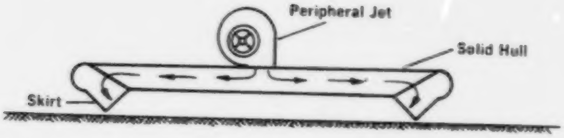
CONCEPT REMOTE CONTROLLED HOVERCRAFT VEHICLE FOR SPILL RECONNAISSANCE No. 157

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
*	*	*	*	*	*	*

Note: This unit is appropriate for containerized gases, liquids and solids involved in spills on land.

DESCRIPTION – A remote controlled vehicle designed to survey a spill site through a television camera and a variety of gas sensors.



OPERATING PRINCIPLE – The skirted hovercraft operates as a ground-effect machine (GEM): lifting and traversing thrust is obtained by the action of air forced against the ground. An "auto pilot" on board the vehicle controls the direction and magnitude of thrust to compensate for the ground terrain, freeing the operator to control the craft's speed, lift and ancillary equipment by radio frequency.

PHYSICAL SPECIFICATIONS – The data given here represent the proposed design specifications for the GEM Hovercraft:

Diameter:	2.44 m (8 ft)
Weight:	136 kg (300 lb)
Power:	Graphite Composite Batteries (990 Wh/kg) and brushless, selenium-cobalt DC electric motors for main propulsion. Thrust, braking and yaw movements are provided by two 508 mm (20 in) variable, reverse pitch, ducted rotors.
Body:	Sandwich-panel construction, using Nomex honeycomb filler between Kevlar face sheets.

OPERATING SPECIFICATIONS –

Characteristic	Proposed Specifications
Maximum Velocity	3 m/s (10 fps)
Maximum Grade Capability	20 degrees
Maximum Crosswind (at forward velocity of 1.2 m/s (4 fps))	46 km/h (25 knots)
Maximum Obstacle Height	46 cm (18 in)
Range from Command Station	800 m (0.5 mi)
In-flight Endurance (new batteries, maximum power consumption)	1.5 h
Turning Circle Diameter	0 cm (Can rotate around its own axis).

STATUS OF DEVELOPMENT AND USAGE – The City of Oxnard Fire Department and Developmental Sciences, Inc. were contracted to develop a full-scale unit for the EPA's Oil and Hazardous Materials Spills Branch under Grant No. R-805365. At the end of 1983, a half-scale model had been constructed and tested.

PERFORMANCE – Refer to report listed in next section.

AVAILABILITY AND COMMERCIAL INFORMATION — A complete report, entitled "Design of a Remotely Controlled Hovercraft Vehicle for Spill Reconnaissance", (Order No. PB 84-124 904; Cost: $8.50, subject to change) will be available only from:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
U.S.A.
Telephone (703) 487-4650

The study was performed by:

City of Oxnard Fire Department
251 South C Street
Oxnard, CA 93030
U.S.A.
Contact: Henry Gustafson and Roy Furr

and

Development Sciences, Inc.
P.O. Box 1264
City of Industry, CA 91749
Telephone (213) 330-6865
Contact: Keith Souter and Gerald Seemann

for U.S. Environmental Protection Agency
Oil and Hazardous Materials Spills Branch
Industrial Environmental Research Laboratory-Ci
Edison, NJ 08837
U.S.A.
Telephone (201) 321-6634
Contact: Mr. John E. Brugger

OTHER DATA — Other remote controlled vehicles known as the "SNAIL" and "FIRECAT" have been developed for firefighting. These could also be applicable to hazardous material spills. Refer to "Snail - A Remotely Controlled Countermeasure Device", by Louis A. Witzeman, Rural/Metro Fire Department, Inc., Scottsdale, Arizona; Proceedings of the 1974 National Conference on Control of Hazardous Materials Spills, San Francisco, CA, p. 219-221 (August 25-28, 1974).

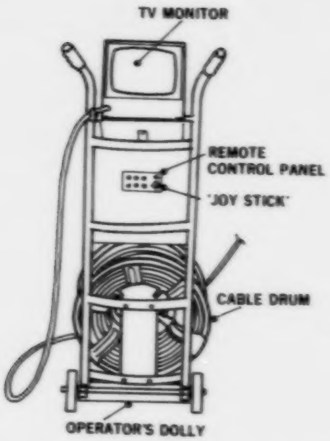
PRODUCT RMI (REMOTE MOBILE INVESTIGATOR) **No. 158**

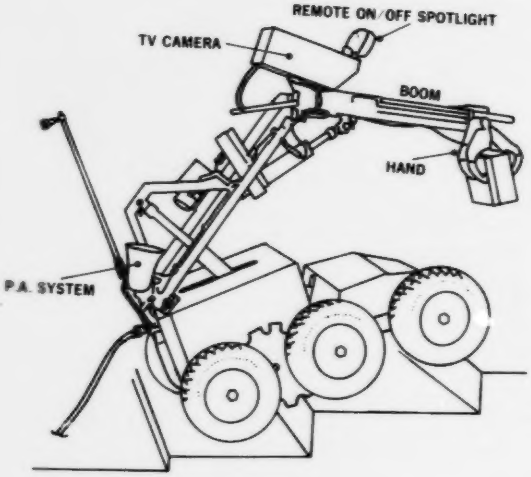
APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
*	*	*	*	*	*	*

Note: This unit is appropriate for containerized gases, liquids and solids involved in spills on land.

DESCRIPTION – The RMI is a remote-controlled vehicle especially designed for surveillance and minor manipulation of tools in hazardous environments, such as explosive disposal, toxic vapour or flammable chemical spills, firefighting, radioactive material handling, etc.





OPERATING PRINCIPLE – This low-profile, six-wheeled vehicle is powered by on-board batteries and directed by signals delivered through a cable from a remote control station. A mechanical claw or other tools are manipulated at the end of boom which is flexible in the vertical plane. The operator monitors the area immediately surrounding the vehicle through a television camera mounted on the arm.

PHYSICAL SPECIFICATIONS (for Mark-3)

Chassis:	1016 x 660 x 475 mm (40 x 26 x 18 in) (length x wide x height)		
	Ground Clearance	127 mm	(5 in)
	Height with Boom Structure Down	711 mm	(28 in)
	Height with Boom Structure Up	1524 mm	(60 in)
	Height of Front Arm (Arm Horizontal)	1219 mm	(48 in)
	Length of Back Arm	787 mm	(31 in)
	Length of Front Arm	559 mm	(22 in)
	Hand Maximum Opening	159 mm	(6 1/4 in)
	Weight	104 kg	(230 lb)

Boom composed of two arms, each powered hydraulically. Front arm fitted with universal adaptor connection for attaching various tools.

Boom structure easily removed from main chassis by removing two pins and one multi-connector.

Two 12-volt lead-acid batteries.

Battery charger and connecting plug.

Low battery indicator.

Six 305 mm (12 in) rubber tires.

TV System:	Camera: Tube 1.7 cm (2/3 in) Vidicon. 360°C (680°F) Pan Operation. Spot light mounted on camera. C-mount, F1.8, 9 mm (0.35 in) lens. Video tape recorder plug. X-Tal controlled sync. Loud speaker.
Operator's Dolly:	Cable drum with 61 m (200 ft) of 11 mm (0.45 in) diameter signal cable. 23 cm (9 in) TV monitor. Removable operator's control box. Intercom System (12 W). 12 V battery and charger.
Additional Equipment:	Disrupter. X-Ray system 10 kg (22 lb), 150 kVP Stethoscope. Foam delivery system. Car hook. Other items available on request.

OPERATING SPECIFICATIONS –

5 hours operation of fully charged batteries.
Maximum speed: approximately 5 km/h (3 mph).
Proportional drive system with "Joy Stick" control for smooth operation.
Lifting capacity: approximately 31 kg (70 lb).
Claw has "soft touch" for fragile objects and a powerful grip for heavy objects.

STATUS OF DEVELOPMENT AND USAGE – The RMI has been developed and modified to the model of Mark 5 (Summer 1984). The basic specifications are similar to those of the Mark 3 outlined under PHYSICAL SPECIFICATIONS. Modifications have been made in close collaboration with the Royal Canadian Mounted Police as they have employed RMI units across Canada for work with explosives. The RCMP use units fitted with mechanical claws and a shotgun for detonating explosives or flammable materials from safe distances.

The manufacturer will construct RMI units to customer's specifications. This design flexibility allows for adaptation of the RMI to respond to hazardous material spills.

PERFORMANCE – Documentation regarding the use of RMI not available; has been used to retrieve spilled fuel bundles at the Bruce Nuclear Generating Station, resulting in a purchase of some units by Ontario Hydro. National Defense and the RCMP have also purchased several units for surveillance purposes and work with explosives. RMI offers several advantages over European or American units.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Pedsco Canada Ltd.
180 Finchdene Sq., Unit 3
Scarborough, Ontario
CANADA
M1X 1A8
Telephone (416) 298-9989
Contact: Mr. Bob Pederson

Pedsco will consider modifications to the RMI to suit an individual customer's requirements.

OTHER DATA – The RMI Mark 5 costs approximately $21 000 (CDN) depending on the accessories included (July, 1984).

Reference: Ron Purvis, personal communication, R&D Coordinator, Explosives Technology Unit, Royal Canadian Mounted Police (July 4, 1984).

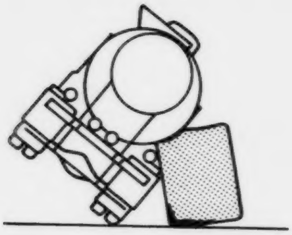
PRODUCT SAFELIFT AIR CUSHION SYSTEM **No. 159**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
*	*	*	*	*	*	*

Note: Applicable for lifting containers on land which may contain gases, liquids or solids.

DESCRIPTION – Low pressure air cushions designed to "lift and roll" large loads such as tank trucks and rail tank cars, locomotives, and aircraft.



OPERATING PRINCIPLE – Starter cushions are inserted beneath the load at equal intervals and inflated by a compressor. Larger cushions are inserted and inflated in succession until the load is pushed upright.

PHYSICAL SPECIFICATIONS –

All cushions:
- square top and bottom faces
- top and bottom faces are "Hi-Grip" rubber

SQ72 and SQ84 models are reinforced internally in the top and bottom to keep the cushion rigid when full inflated.

Cushion	
SQ24	Starter cushion, lifts 2860 kg (6300 lb) 61 cm (24 in) high. Requires about an 4 cm (1.5 in) gap for insertion.
SQ42	Sloping top. Vertically lifts (up to 127 cm (50 in) high) loads of 7330 kg (16 128 lb) @ 48 kPa (7 psi) or 10 470 kg (23 040 lb) @ 69 kPa (10 psi).
SQ72	Vertically lifts loads of 7330 kg (16 128 lb) @ 48 kPa (7 psi) or 10 470 kg (23 040 lb) @ 69 kPa (10 psi).
SQ84 IS	Sloping top and bottom (2.1 m (7 ft) outside, 1.8 m (6 ft) inside), with built in tie down straps. For lifting loads where the top is lower than the bottom (eg. truck overturned into a ditch). Vertically lifts loads of 7330 kg (16 128 lb) @ 48 kPa (7 psi) or 10 470 kg (23 040 lb) @ 69 kPa (10 psi).
GIANT ONE	2.4 x 1.5 x 1.8 m (8 x 5 x 6 ft). Lifts 18 180 kg (40 000 lb) vertically.
GIANT TWO	3 x 1.5 x 2.1 m (10 x 5 x 7 ft). Lifts 22 270 kg (50 000 lb) vertically and "lifts and rolls" 34 100 kg (75 000 lb).

Kits

Quantity of Cushions

Kit	SQ24	SQ42	SQ72	SQ84 IS	GIANT ONE	GIANT TWO
A	2	4	—	—	—	—
B	2	—	4	—	—	—
C	2	—	—	4	—	—
D	2	—	—	—	1	—
E	2	—	—	—	—	1

All kits include a compressor valve block, 4 x 6.1 m (20 ft) hoses and 2 x 12.2 m (40 ft) hoses.

OPERATING SPECIFICATIONS – Recommend washing cushions immediately after use in a spill environment of acid, caustic, or solvents due to the nature of construction of the seams.

Steel grates placed beneath the cushions are suggested for increased traction and separation from the spilled material on the ground.

Maximum inflation pressure: Giant cushions 34 kPa (5 psi)
Others 48 kPa (7 psi)

Place cushions near the outside edge of the load, not under the center line of the load.

The compressor should pump less than 1.4 m^3/min (50 cfm) and at a pressure less than 207 kPa (30 psi).

Under hot conditions, deflate cushions as soon as possible after completing lift to prevent further lifting by the expansion of hot air in the cushions.

STATUS OF DEVELOPMENT AND USAGE – Commercially available for lifting overturned vehicles on highways or railways.

PERFORMANCE – Safelift Air Cushion systems have been used by towing companies in the United States for several years. Contact the manufacturer listed below to discuss their applications.

AVAILABILITY AND COMMERCIAL INFORMATION –

Wreckers International Limited
Port Commerce Centre
1961 West 9th Street
Riviera Beach, FL 33404-7005
U.S.A.
Telephone (305) 844-5594
Contact: Bill Jackson, President
Mark Anderson

OTHER DATA – None obtained.

Reference: personal communication, Mr. Wyttkop, Pennington Wrecker Service (a salvage contractor), NJ (October 24, 1983), telephone (609) 737-2958.

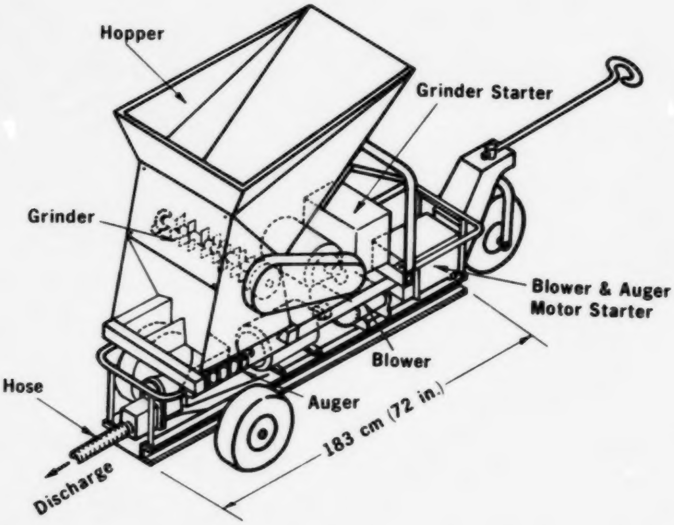
PRODUCT SOLIDS BROADCASTER (MSA ROCKDUSTER) No. 160

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
				*	*	*

Note: Applicable for spreading powdered treating agents over spills on land or water.

DESCRIPTION – A portable high-pressure distributor for general application of bagged rockdust. The unit could be used in hazardous material spills by replacing rockdust with treating agents. It consists mainly of blower, motor, conveyor screw (auger) assembly, hopper and hoses.



OPERATING PRINCIPLE – The treating material is fed through the hopper and into the conveyor screw assembly. As the motor turns the conveyor screw, the material drops into a blowing air stream and discharges out of the hose.

PHYSICAL SPECIFICATIONS –

Bantam™ 400 Rockdust Distributor

Motor: Intermittent-duty 5 hp
Hopper Capacities: 18 kg, 36 kg, 72 kg (40 lb, 80 lb, 160 lb)
Power Requirements 250 VDC, 550 VDC, 440 VAC, 550 VAC, or 90 VDC (with 15 m power cable).
Hose: Plastic-reinforced, 51 mm (2 in) dia. 15 m (50 ft) long.

Models	Height (mm) (in)	Weight (kg) (lb)	Hopper Capacity (kg) (lb)	Length (m) (ft)
Skid-mounted, less hopper	381 (15)	295 (650)	—	1.9 (6)
Skid-mounted, with small hopper	559 (22)	313 (690)	36 (79)	1.9 (6)
Skid-mounted, with large hopper	686 (27)	318 (701)	72 (158)	1.9 (6)
Quick-detachable truck, adds	229 (9)	79 (174)	—	0.5 (1.6)
Permanent truck, adds	178 (7)	50 (110)	—	0.5 (1.6)

Hydraulic Bantam Rockdust Distributor

Motor: Hydraulic
Power Requirements: 55 bar (800 psi), 30-45 L/min (8 to 12 U.S. gpm)
Hose: Plastic-reinforced, 51 mm (2 in) dia., 15 m (50 ft) long
Dimensions, less hopper: 0.34 x 1.4 m (1 x 4.5 ft) (high x long)
Hopper Capacities: 18 kg, 36 kg, 72 kg (40 lb, 80 lb, 160 lb)
Weight: 114 kg (250 lb)

OPERATING SPECIFICATIONS –

Based on rockdust (ground limestone: 30% thru 20 mesh 70% thru 200 mesh). Use with other materials may require machine alterations.

Flowrates (through 51 mm (2 in) hose):

	kg/min (lb/min)	with	Length of hose (m) (ft)
Bantam 400	45 (100)		8 (25)
	23 (50)		30 (100)
	8 (17)		122 (400)
Hydraulic Bantam	31 (68)		8 (25)
	24 (53)		30 (100)
	16 (35)		77 (250)

Bantam/Trickle Duster™ Combination Rockduster

Same flow rates as Bantam™ 400 Rockdust Distributor plus the Trickle Duster Hopper with a capacity of 182 kg (400 lb) has flow rates of (through a 51 mm (2 in) hose):

1.6 kg/min with 8 m hose (3.5 lb/min with 25 ft hose)
1.3 kg/min with 15 m hose (2.8 lb/min with 50 ft hose)
1.0 kg/min with 100 m hose (2.2 lb/min with 400 ft hose)
0.4 kg/min with 106 m hose (0.8 lb/min with 350 ft hose)

The Trickle Duster Hopper can be detached and located up to 30 m (100 ft) away from the Bantam for remote operation.

STATUS OF DEVELOPMENT AND USAGE – The line of MSA Rockdust Distributors is undergoing redesign. New data will be available in the Fall, 1984.

These are being marketed primarily for the mining and construction industries.

PERFORMANCE – The MSA Rockdust Distributors have been incorporated into hazardous material spills countermeasures systems such as the EPA Mobile Dispersing System (MDS) for spreading the "EPA's Multipurpose Gelling Agent" (see Entry No. 76) and the EPA concept of "Vapour Suppression by Artificial Cooling" (Entry No. 30).

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

MSA Research Corporation
Evans City, PA 16033
U.S.A.
Telephone (412) 538-3510
Contact: Mr. C.H. Staub,
Director of Marketing

In Canada:

Mine Safety Applications (MSA) Co. of Canada Ltd.
148 Norfinch Dr.
Downsview, Ontario
M3N 1X8
Telephone (416) 667-9400
Telex 065-27286

OTHER DATA – None obtained.

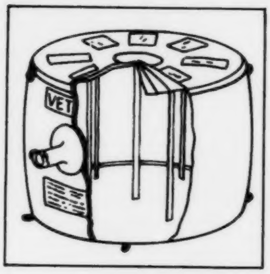
PRODUCT VETTER POWER LIFTING BAGS **No. 161**

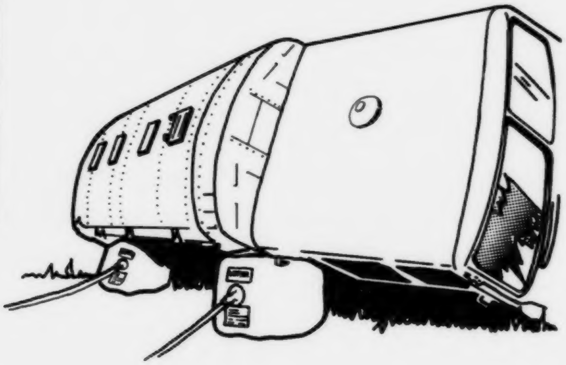
APPLICABILITY

Gas	Liquid Sol	Liquid Fl	Liquid Sk	Solid Sol	Solid Fl	Solid Sk
*	*	*	*	*	*	*

Directly applicable to container not material.

DESCRIPTION – Air-inflated lifting bags reinforced with steel cord and fabricated in flat models designed for the lifting, pushing, prying or bending of heavy objects, including derailed tank cars, tank trucks, and other heavy equipment, necessitated during rescue work repairs, or the cleanup of spills.





OPERATING PRINCIPLE – The lifting bag is positioned in its deflated state either alone or with harnesses and/or straps and then inflated via pressure regulator by compressed air cylinder, manual pump, truck tire or other source.

PHYSICAL SPECIFICATIONS – Nine Vetter Mini Bags are available constructed of steel cord-reinforced Neoprene and synthetic rubber in 6 layers.

Model	Size (cm)	Height (cm)	Weight (kg)
V10	37 x 37	2.5	4.5
V12	32 x 52	2.5	5.5
V18	47 x 52	2.5	8.0
V24	52 x 62	2.5	10.3
V24L	31 x 102	2.5	10.2
V31	65 x 69	2.5	17
V40	78 x 69	2.5	19.8
V54	86 x 86	2.5	26
V68	95 x 95	3.0	39

A wide range of accessories is available which includes dual safety controller, safety valves, pressure gauges, compressed air hose, pressure reducer, tire-inflating connector, hand and foot pumps, rescue kits, etc.

OPERATING SPECIFICATIONS –

Model	Max. Lift (t)	Max. Lift (cm)	Max. Pressure (bar)	Burst. Pressure (bar)	Inflation Time (s)
V10	9.6	20.3	8	48.3	3.8
V12	12.0	20.0	8	71.3	4.8
V18	17.7	27.0	8	38.7	9.0
V24	24.0	30.6	8	48.3	13.8
V24L	24.0	20.1	8	74.3	9.9
V31	31.4	37.0	8	42.0	23.7
V40	39.6	40.2	8	35.0	31.1
V54	54.4	47.8	8	35.5	51.9
V68	67.7	52.0	8	34.7	66.3

Material of construction is: oil-resistant
self-extinguishing
anti-static
retains flexibility to -60°C
has anti-slip surface

A list of chemical compatibility can be obtained from the manufacturer.

STATUS OF DEVELOPMENT AND USAGE – Commercial product designed for lifting or prying objects where rescue, repair or other task would be facilitated. Utility of the lifting bag during the cleanup of hazardous material spills would depend upon the circumstances of the incident. Example applications cited by the manufacturer refer mainly to equipment repairs, construction, and rescue.

PERFORMANCE – Documentation of the performance of lifting bags used in hazardous material spill response was not received.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Manfred Vetter GmbH
D-5352 Zuelpich
West Germany
Telephone 02252-2081
Telex 8869818

Canadian Distributor:

Safety Supply Canada
214 King Street East
Toronto, Ontario
M5A 1J8
Telephone (416) 292-8888
(Branches are located throughout Canada.)

OTHER DATA – The manufacturer also fabricates Vetter leak-sealing bags. See Section 1.1 Leak Mitigation Entry No. 9.

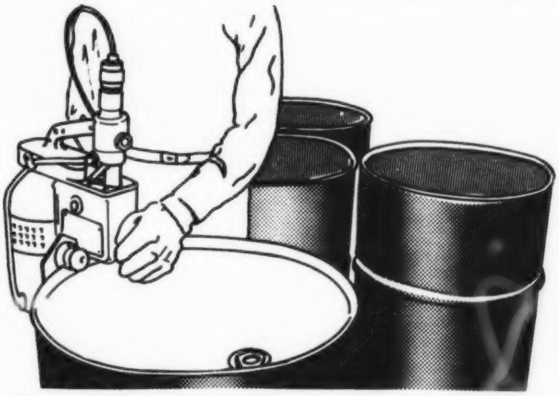
PRODUCT WIZARD SELF- PROPELLED DRUM DEHEADER **No. 162**

APPLICABILITY

Gas	Liquid			Solid		
	Sol	Fl	Sk	Sol	Fl	Sk
	*	*	*	*	*	*

Note: This tool is designed for metal drums containing solids or liquids.

DESCRIPTION – A portable, powered device for removing the heads of steel drums.



OPERATING PRINCIPLE – A round cutting blade is guided in the horizontal plane around the edge of a drum. The dulled out edge is firmly pressed against the drum's side leaving a safe, smooth rim.

PHYSICAL SPECIFICATIONS –

Standard Electric Models

Models GS, HS and JS: 110 V, 60 Hz, single-phase TEFC gearmotor.
Models GS-3, HS-3, and JS-3: 220/440 V three-phase TEFC gearmotor.
Optional electric models FS50-3, HS50-3, and JS50-3: 220/440 V, 50 Hz, three-phase TEFC gearmotor.
All of the above include swivel cord connectors.
Optional Explosion-proof Models GE, HE and JE.

Standard Air Models

Models GA, HA and JA: 1/2 hp developed with 11.8 L/s (25 cfm) of air at 275 kPa (40 psi).

OPERATING SPECIFICATIONS –

Three ways to cut:

- INSIDE CHIME CUT, "G" MODELS:
  Model G leaves five layers of metal for maximum strength. Leaves "hands-safe" edge on drum. Cover not reusable. Best used on empty or partially empty drums. Drums to be reused for storage or shipping container.
- OUTSIDE CHIM CUT' "H" MODELS:
  Adjust to all chime widths. Model H leaves four layers of metal intact. Heads can be reused as covers. Especially useful when deheading full drums.
- OUTSIDE DRUM CUT, "J" MODELS:
  Model J is fastest opening method for drums to be scrapped or where chime re-rolling is intended. Chime comes off with head.

STATUS OF DEVELOPMENT AND USAGE – Commercially available and widely used wherever metal drums are used.

PERFORMANCE – Used to dehead more than 2 500 drums at Schenectady Chemicals resin plant, Rotterdam Junction, New York, personal communication with manufac-turer.

AVAILABILITY AND COMMERCIAL INFORMATION –

Manufacturer:

Wizard Drum Tools
1263 North 70th St.
Milwaukee, WI 53213
U.S.A.
Telephone (414) 476-7717
TWX 910-262-1189

Distributor:

BASCO
Barrel Accessories & Supply Co.
4647 West 47th St.
Chicago, IL 60632
U.S.A.
Telephone (312) 767-8100 or
1-800-621-0621

Consult Fraser's Canadian Trade Directory for a complete listing of drum accessories dealers in Canada.

OTHER DATA – Wizard also markets a "DUO OPENER" (powered by any 13 mm (1/2 in) industrial drill), "All-Plug" Universal Wrench, De-kinker, Drum Opener Tower (holds deheader equipment at proper working height) and a Manual 400 opener (see Entry No. 155).

APPENDIX A

CLEANUP CONTRACTORS

CANADA

D & D Disposal Services Ltd.
P.O. Box 372
Smithville, Ontario
L0R 2A0
Telephone (416) 957-3323
Contact: Mr. T.W. Drew

KINETIC CONTAMINANTS CANADA
LIMITED
Nisku Industrial Park
Nisku, Alberta
Telephone (403) 955-7161
Contact: Mr. A. Leander

SANIVAN INC.
1705 3rd Avenue, P.A.T.
Montreal, Quebec
H1B 5M9
Telephone (514) 353-9170
Contact: Mr. G. Allard

TRICIL INC.
6785 Route 102
Ste Catherine, Quebec
J0I 1E0
Telephone (514) 632-6640
Contact: Mr. J. Brassard

UNITED STATES

BROWNING-FERRIS INDUSTRIES, INC.
Fannin Bank Building
Houston, TX 77030
Telephone (713) 890-8100 or
(713) 790-1611
Contact: Mr. R.A. Johnson, Vice President
Chemical Waste Systems

CROWLEY ENVIRONMENTAL SERVICES
CORPORATION
3400 East Marginal Way South
Seattle, WA 98134
Telephone (206) 682-4898
Contact: Mr. M.A. Graig, Marketing Manager

ENVIRONMENTAL EMERGENCIES SERVICES
COMPANY
Portland Division
Ft. of N. Portsmouth
P.O. Box 3320
Portland, OR 97208
Telephone (503) 285-9111
Contact: Mr. B. Connelly

ENVIRONMENTAL POLLUTION CONTROL
SERVICES, INC.
Subsidiary of Coastal Industries, Inc.
P.O. Box 5555
Akron, OH 44313
Telephone (216) 867-8925
Contact: Mr. K. Gossard

FONDESSY ENTERPRISES, INC.
Associated Chemical and Environmental
Services, Inc. (ACES)
876 Otter Creek Road
P.O. Box 7571
Oregon, OH 43616
Telephone (419) 726-1521 (24 hrs)

IT SERVICES, INC.
336 W. Anacheim
Wilmington, CA 90744
Telephone (213) 830-1720
Contact: Mr. R. Allison

JET LINES SERVICES, INC.
P.O. Box 180
441 R Canton Street
Stoughton, MA 02072
Telephone (617) 843-2829
Contact: Mr. J. Hickman

MARINE POLLUTION CONTROL, INC.
460 Terryville Road
Port Jefferson Station
Long Island, NY 11776
Telephone (516) 473-9132

UNITED STATES - continued

NEW ENGLAND POLLUTION CONTROL COMPANY, INC.
Newark, NJ
Telephone (201) 589-1282
Contact: Mr. L. Green

OH MATERIALS COMPANY
P.O. Box 1022
Findlay, OH 45840
Telephone (419) 423-3526
Contact: Mr. J. Zitkovic

PEABODY CLEAN INDUSTRY
Hazardous Materials Division
2 Lincoln Street
Linden, NJ 07036
Telephone (201) 862-2722

SCA CHEMICAL WASTE SERVICES, INC.
60 State Street
Boston, MA
Telephone (617) 367-8300
Contact: Mr. C.T. Tiller

SED INC.
Box 1306
Waukesha, WI 53187
Telephone (414) 784-3740

UNITED STATES TESTING COMPANY
1415 Park Avenue
Hoboken, NJ
Telephone (201) 792-2400
Contact: Mr. E. Rider

WASTE MANAGEMENT INC.
900 Jorrie Boulevard
Oak Brook, IL 60521
Telephone (312) 654-8800
Contact: Mr. D. Price, General Manager
Chemical Waste Operations

APPENDIX B

CANADIAN CHEMICAL SUPPLIERS

A & B CHEMICAL PRODUCTS
R.R. 4
Stouffville, Ontario
L0H 1L0
Telephone (416) 294-5054

A & C AMERICAN CHEMICAL LIMITED
3010 De Baene Street
St. Laurent, Quebec
H4S 1L2
Telephone (514) 336-1493
(514) 336-0508

A & K PETRO-CHEM INDUSTRIES LIMITED
710 Arrow Road
Weston, Ontario
M9M 2M1
Telephone (416) 746-2991

ADRO CHEMICAL PRODUCTS
5740 Hamilton Street
Montreal, Quebec
H4E 3B8
Telephone (514) 766-2383
(514) 766-2384

AIR PRODUCTS
2090 Steeles Avenue
Brampton, Ontario
L6T 1A7
Telephone (416) 791-2530

ALCAN CANADA PRODUCTS LIMITED
1000 Sherbrooke Street West
Suite 2000
Montreal, Quebec
H3G 1G7
Telephone (514) 877-2340

ALCHEM INC.
P.O. Box 5002
Burlington, Ontario
L7R 3Y9
Telephone (416) 632-8791

ALDERT CHEMICALS LIMITED
648 Finch Avenue East
Willowdale, Ontario
M2K 2E6
Telephone (416) 223-0404

ALKARIL CHEMICALS LIMITED
3265 Wolfedale Road
Mississauga, Ontario
L5C 1V8
Telephone (416) 270-5534

ALLIED CHEMICAL CANADA LIMITED
237 Hymus Boulevard
Pointe Claire, Quebec
H9R 1G3
Telephone (514) 697-9210

AMOCO CANADA PETROLEUM
COMPANY LIMITED
444 - 7th Avenue S W
Calgary, Alberta
T2P 0Y2
Telephone (403) 267-0001

ANACHEMIA LIMITED
P.O. Box 147
Lachine, Quebec
H8S 4A7
Telephone (514) 489-5711

ARLISS CHEMICAL COMPANY INC.
325 Hymus Boulevard
Point Claire, Quebec
H9R 1G8
Telephone (514) 694-2170

BASF CANADA LIMITED
5850 Cote De Liesse
Montreal, Quebec
H4T 1C1
Telephone (514) 341-5411

BATE CHEMICAL COMPANY LIMITED
160 Lesmill Road
Don Mills, Ontario
M3B 2T7
Telephone (416) 445-7050

BAYER (CANADA) INC.
7600 Trans-Canada Highway
Pointe Claire, Quebec
H9R 1C8
Telephone (514) 697-5550

BETZ LABORATORIES LTD-LTEE
3026 Solandt Road
Kanata, Ontario
K2K 2A5
Telephone (613) 592-5050

BORDER CHEMICAL DIVISION OF
BORDER FERTILIZER LIMITED
P.O. Box 100
Transcona, Manitoba
Telephone (204) 222-3276

C-I-L INC.
45 Sheppard Avenue East
Willowdale, Ontario
M2N 5S8
Telephone (416) 226-7532
(416) 226-7250

CALGON CANADA
27 Finley Road
Bramalea, Ontario
L6T 1B2
Telephone (416) 457-5310

CANADA COLORS & CHEMICALS LIMITED
80 Scarsdale Road
Don Mills, Ontario
M3B 2R7
Telephone (416) 924-6831

CANADA PACKERS INC.
CHEMICAL DIVISION
5100 Timberlea Boulevard
Mississauga, Ontario
L4W 2S5
Telephone (416) 624-7000

CANADIAN HANSON LIMITED
45 Vansco Road
Toronto, Ontario
M8Z 5J7
Telephone (416) 255-1371

CANADIAN LIQUID AIR COMPANY LIMITED
1155 Sherbrooke Street West
Montreal, Quebec
H3A 1H8
Telephone (514) 842-5431

CANADIAN OCCIDENTAL PETROLEUM
INDUSTRIAL CHEMICALS DIVISION
100 Amherst Avenue
North Vancouver, B.C.
V7H 1S4
Telephone (604) 929-3441

CANADIAN OXYGEN LIMITED
355 Horner Avenue
Toronto, Ontario
M8W 1Z7
Telephone (416) 251-5241

CAPO POLISHES LIMITED
2279 Fairview Street
Burlington, Ontario
L7R 2E3
Telephone (416) 827-7890

CELANESE CANADA INC.
Two Robert Speck Parkway
Mississauga, Ontario
L4Z 1H8
Telephone (416) 276-9272
(416) 276-9333

CHEMSOLVE LIMITED
505 Consumers Road
Willowdale, Ontario
M2J 4V8
Telephone (416) 493-2300

CHURCH & DWIGHT LIMITED
75 The Donway West
Don Mills, Ontario
M3C 2E9
Telephone (416) 444-5241

CIBA-GEIGY CANADA LIMITED
205 Bouchard Boulevard
Dorval 780, Quebec
Telephone (514) 631-4841

CLOUGH CHEMICAL COMPANY LIMITED
178 St. Peter Street
St. Johns, Quebec
J3B 5W4
Telephone (514) 866-8656
(514) 346-6848

COTE CHEMICALS INC.
111 Bombardier Park
Chateauguay Centre, Quebec
J6J 3X0
Telephone (514) 691-6260

CYANAMID CANADA INC.
2255 Sheppard Avenue East
Willowdale, Ontario
M2J 4Y6
Telephone (416) 498-9405

DEARBORN CHEMICAL COMPANY LIMITED
P.O. Box 3060, Station "A"
Mississauga, Ontario
L5C 2S9
Telephone (416) 279-2222

DEMPSEY FRANK E & SONS LIMITED
47 Davies Avenue
Toronto, Ontario
M4M 2B1
Telephone (416) 461-0844

DIAMOND SHAMROCK CANADA LIMITED
P.O. Box 5123, Station "E"
Hamilton, Ontario
L8S 4L4
Telephone (416) 525-4660

DOMTAR CHEMICALS GROUP
CDC DIVISION
1136 Matheson Boulevard
Mississauga, Ontario
L2W 2V4
Telephone (416) 625-4240
(416) 624-5700

DOMTAR CONSTRUCTION MATERIALS LIMITED
2001 University Street
Montreal, Quebec
H3A 2A6
Telephone (514) 282-5456
(514) 282-8486

KERT CHEMICAL INDUSTRIES LIMITED
171 Fenmar Drive
Weston, Ontario
M9L 1M8
Telephone (416) 749-5220

KINGSLEY & KEITH (CANADA) LIMITED
310 Victoria Avenue
Montreal, Quebec
H3Z 2M8
Telephone (514) 487-1550

LAWRASON'S CHEMICALS LIMITED
180 Adelaide Street South
P.O. Box 2425
London, Ontario
N6A 4G3
Telephone (519) 686-9335
(800) 265-4694

LEINER P & SONS (CANADA) LIMITED
2175 Sheppard Avenue East
Willowdale, Ontario
M2J 1W7
Telephone (416) 491-8997

LEVITT-SAFETY LIMITED
33 Laird Drive
Toronto, Ontario
M4G 3S9
Telephone (416) 425-8700

LIME & SALT DIVISION
DOMTAR CHEMICALS GROUP
395 Maisonneuve Boulevard West
Montreal, Quebec
H3C 3M3
Telephone (514) 282-5400

LIQUID CARBONIC CANADA LTD/LTEE
1945 Graham Boulevard
Montreal, Quebec
H3R 1H1
Telephone (514) 731-6461

LOMAS L V CHEMICAL COMPANY LIMITED
6365 Northwest Drive
Mississauga, Ontario
L4V 1J8
Telephone (416) 741-6602
(416) 677-6781

MAGNUS CHEMICALS LIMITED
190 Boulevard Industriel
Boucherville, Quebec
J4B 2X3
Telephone (514) 655-1344

MALLINCKRODT CANADA INC.
600 Delmar Avenue
Pointe Claire, Quebec
H9W 1E6
Telephone (514) 695-1220

MOGUL CANADA
8400 Cote De Liesse Road
St. Laurent, Quebec
H4T 1G7
Telephone (514) 735-5541

MONSANTO CANADA LIMITED
2000 Argentia Road
P.O. Box 787
L5M 2G4
Telephone (416) 826-9222

NATIONAL SILICATES LIMITED
P.O. Box 69
Toronto, Ontario
M8V 3S7
Telephone (416) 255-7771

PENNWALT OF CANADA LIMITED
700 Third Line
Oakville, Ontario
L6J 5A3
Telephone (416) 827-9841

PIGMENT & CHEMICAL COMPANY LIMITED
5757 Cavendish Boulevard
Montreal, Quebec
H4W 2W8
Telephone (514) 489-9396

QUADRA CHEMICALS LIMITED
7575 Trans Canada Highway
St. Laurent, Quebec
H4T 1V6
Telephone (514) 337-2454

QUATIC CHEMICALS LIMITED
61 Lewis Road
Guelph, Ontario
N1H 6M6
Telephone (519) 821-7780

ROHM & HAAS CANADA LIMITED
2 Manse Road
West Hill, Ontario
M1E 3T9
Telephone (416) 364-3234

SAFETY SUPPLY COMPANY
214 King Street East
Toronto, Ontario
M5A 1J8
Telephone (416) 364-3234

SHEFFORD CHEMICALS LIMITED
1028 Principale
Granby, Quebec
J2G 8C8
Telephone (514) 378-0125

SHELL CANADA LIMITED
505 University Avenue
Toronto, Ontario
M5G 1X4
Telephone (416) 866-7111

SIGNAL CHEMICALS COMPANY LIMITED
12 Carlaw Avenue
Toronto, Ontario
M4M 2R7
Telephone (416) 461-8181

ST. LAWRENCE CHEMICAL COMPANY
(SALES) LIMITED
5405 Pare Street
Montreal, Quebec
H4P 1P7
Telephone (514) 731-3628

STANCHEM DIVISION
PPG INDUSTRIES CANADA LIMITED
5029 St. Ambroise Street
Montreal, Quebec
H4C 2E9
Telephone (514) 933-6721

STEEL BROTHERS CANADA LIMITED
LIME DIVISION
4836 - 6 Street N E
Calgary, Alberta
T2E 3Z9
Telephone (403) 276-9335

STEELEY TALC LIMITED
MINERALS GROUP
605 James Street North
Hamilton, Ontario
L8N 3S9
Telephone (416) 527-3671

SUMMIT LIME WORKS LIMITED
P.O. Box 700
Lethbridge, Alberta
T1J 3Z6
Telephone (403) 329-0743

TRAVIS CHEMICALS
715 - 5th Avenue S.W.
Suite 1710
Calgary, Alberta
T2C 2X6
Telephone (403) 263-8660

UNITED CHEMICALS LIMITED
P.O. Box 2090
Saskatoon, Saskatchewan
S7K 3S7
Telephone (306) 382-4088

VAN WATERS & ROGERS LIMITED
9800 Van Horne Way
Richmond, B.C.
V6X 1W5
Telephone (604) 273-1441

WINFIELD CHEMICAL INDUSTRIES
LIMITED
P.O. Box 1134
Woodstock, New Brunswick
E0J 2B0
Telephone (506) 328-6851